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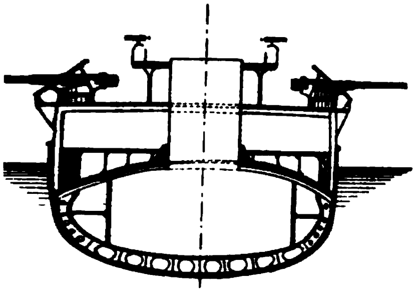

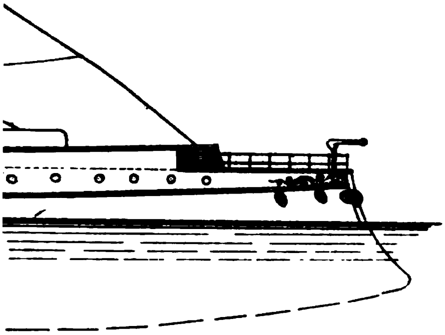

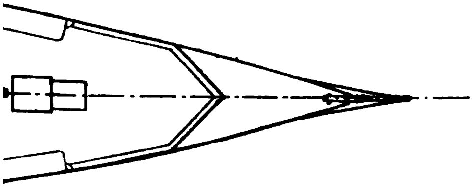

OFFICE OF NAVAL INTELLIGENCE,

GENERAL INFORMATION SERIES, NO. X.

INFORMATION FROM ABROAD.

VII. 2662.10

THE YEAR'S NAVAL PROGRESS. (third)

NUAL OF THE OFFICE OF NAVAL INTELLIGENCE.

JULY, 1891.

U. S. —

OFFICE OF NAVAL INTELLIGENCE,

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THE YEAR'S NAVAL PROGRESS.

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INTRODUCTION.

The present volume of the Annual of the Office of Naval Intelligence, which is the tenth in the series of general information from abroad, retains the title of last year's number. It is now impossible for the office to supply most of the previous numbers of the series.

In the notes on navies a new heading, "Ships lost or struck from the list," has been introduced.

Chapter VI treats of the armor question in its present aspect, as viewed in the light of recent practical tests.

Chapter VII presents a view of the different systems of coast defense of various European states.

Chapter X is given in continuation of Chapter VII of No. IX. It deals principally with the question of promotion, a question which is exciting a great deal of attention in several foreign services and is a vital one in our own.

Chapter XI presents a list of some standard works on professional subjects. This list is necessarily incomplete. It has been found impossible to cite authors whose works antedate the year 1885, except in the case of a few standard works that are frequently going through new editions. This office will be glad to receive notice of omissions or errors in this list, with a view to publishing in a future volume a more complete bibliography of the naval profession.

C. H. DAVIS,
Commander, Chief Intelligence Officer.

NAVY DEPARTMENT, *July* 1, 1891.

ERRATA.

Page 196, Fig. 6, for lower "a" read a′.

Page 207, ninth line from top, for "drops" read drop.

Page 214, third line from top, omit "by."

Page 214, seventh line from bottom, insert comma after "circuit."

Page 235, twelfth line, fifth paragraph, insert hyphen after "Pem."

Page 245, first line, fifth paragraph, insert hyphen after "condl."

Page 261, first line, second paragraph, for "Sund" read Sund.

Page 379, fifth line, second paragraph, for "ome" read home.

Page 398, third line of table, for "Dynamite No. 1 ...... 4.6" read Dynamite No. 1 ...... 1.6.

Page 450, sixth line from top, omit comma after "Information."

Page 451, third line from top, for "Lyon" read Lyons.

Page 452, first line, eighth paragraph, for "Treaties" read Treatise.

Page 452, first line, ninth paragraph, for "Treaties" read Treatise.

Page 452, first line, ninth paragraph, for "Electeicity" read Electricity.

Page 458, first line, second paragraph, for "Elemenary" read Elementary.

Page 462, next to last line of second paragraph, for "Mutray" read Murray.

Page 471, first line, second paragraph, for "Vice-Admiral Penhoot" read Vice-Amiral Penhoat.

Page 471, second line, second paragraph, for "avce" read avec.

I.

NOTES ON SHIPS AND TORPEDO BOATS.

UNITED STATES.

The Naval Appropriation Bill for the fiscal year ending June 30, 1891, provides $16,607,000 for "increase of the Navy," and authorizes the construction of one new vessel (protected cruiser No. 13).

So much of the Act approved March 2, 1889, as authorized the construction by contract of one armored steel cruising monitor, is repealed.

VESSELS PROPOSED OR LAID DOWN.

INDIANA—MASSACHUSETTS—OREGON.

(Coast-line battle ships, page 7, General Information Series, No. IX.)

The contracts for these three vessels were awarded in November, 1890; the first two, to the William Cramp & Sons, Ship and Engine Building Company, of Philadelphia, and the last one to the Union Iron Works, of San Francisco. They are all to be completed and ready for delivery on or before the expiration of 3 years from the date of contract.

The estimated cost of the *Indiana* and *Massachusetts* was $3,020,000 apiece, and that of the *Oregon* $3,180,000, but there will be a slight increase on these amounts, due to changes in the original plans.

Armament.—Four 13-inch B. L., eight 8-inch B. L., four 6-inch B. L., twenty R. F. G., four machine guns, and seven torpedo-tubes.

Protection.—A water-line armor belt 7½ feet wide and 18 inches thick; armored redoubts 17 inches thick at each end of the belt extend 3½ feet above the main deck and thus give an armored freeboard of 15 feet 2 inches; these redoubts protect the turning gear of the turrets and all the operations of loading. The turrets for 13-inch guns have 17-inch inclined armor; the 8-inch guns have barbettes of 10 inches, inclined turrets of 8½ inches, and cone bases and loading tubes of 3 inches. The side armor is backed by 6 inches of wood, two ¾-inch plates, and a 10-foot belt of coal, while belts of water-excluding material are worked on the slopes of the armor deck forward and aft. Above the belt armor and extending from redoubt to redoubt the side is protected by 5 inches of steel. The conning tower is 10 inches thick, with a 7-inch tube for protecting the voice pipes, steering connections, etc. The protective deck is [illegible] inches thick over the belt and 3 inches thick forward and abaft it.

Motive power.—Two vertical, triple-expansion engines of 9,000 I. H. P., estimated to give a sustained sea speed of 15 knots.

Dimensions.—Length on the water-line, 348 feet; extreme breadth, 69 feet 3 inches; draught, 24 feet; displacement, 10,231 tons.

NEW YORK.

(Armored cruiser No. 2, page 7, No. IX.)

Bids for the construction of this vessel were opened on June 10, 1890, and the contract awarded to Messrs. Cramp & Sons, of Philadelphia, Pa.

HARBOR-DEFENSE RAM.

(Page 331, No. VIII.)

The contract for the construction of this vessel was made and concluded with The Bath Iron Works on January 28, 1891.

It was at first intended that this vessel should depend for offensive power upon her ram alone, but it has since been decided to give her a light battery of rapid-fire guns (probably four 6-pounders).

Protection.—Deck and side armor from 2½ to 6 inches thick, and 6-inch inclined plates about smokepipe and ventilators; conning tower, 18 inches.

Motive power.—Two horizontal, triple-expansion engines of 4,800 I. H. P., which are to give an average speed of 17 knots during two consecutive hours. (This power may be increased.)

Dimensions.—Length, 251 feet; breadth, 43½ feet; draught, 15 feet; displacement, about 2,100 tons.

To be completed within 18 months from date of contract.

PRACTICE CRUISER.

(Page 9, No. IX.)

The contract to build this ship was given, on July 18, 1890, to the Samuel L. Moore & Sons Company, of Elizabeth, N. J.

She is to be completed and ready for delivery to the Government on or before the expiration of 2 years from the above date.

FIRST-CLASS PROTECTED CRUISER No. 12.

(Page 7, No. IX.)

The contract for this vessel was awarded to Messrs. Cramp & Sons, of Philadelphia, on November 19, 1890. She is in course of construction, and is to be completed on or before the expiration of 2 years and 6 months from date of contract.

Armament.—One 8-inch B. L., two 6-inch B. L., twelve 4-inch R. F. G., twenty-four 1-pounder and 6-pounder R. F. G., four machine-guns, and six torpedo-tubes.

Protection.—In wake of the rapid-fire and machine-guns the ship's side will be armored with 4 and 2-inch plates; the 6 and 8-inch B. L. are protected by heavy shields attached to the gun carriages; a complete protective deck is 2½ to 4 inches thick; conning tower, 5 inches; tubes, 3 inches.

Motive power.—Three sets of vertical inverted triple-expansion engines, working three propellers, are expected to give 21,000 I. H. P. and a speed of 22 knots.

Dimensions.—Length on load line, 412 feet; beam, 58.2 feet; mean draft, 23 feet; displacement, 7,400 tons.

FIRST-CLASS PROTECTED CRUISER No. 13.

A circular inviting proposals for the construction of this vessel was issued by the Navy Department March 11, 1891, and on June 1, 1891, the bids were opened, but the contract has not yet been awarded.

This vessel is to be similar to cruiser No. 12.

FIRST-CLASS PROTECTED CRUISER No. 6.

Proposals were opened on June 10, 1890, and the contract awarded to the Union Iron Works of San Francisco, Cal.

Some modifications have been made in the plans of this vessel so that the description on page 8, No. IX, is not altogether correct.

The armament is now to consist of four 8-inch B. L., ten 5-inch R. F. G., twenty 6-pdr. and 3-pdr. R. F. G., four machine-guns, and six torpedo-tubes.

The 8-inch B. L. are mounted on the main deck forward and aft in the center line on barbettes 4 inches thick, with inclined turrets of the same thickness over the guns. These guns are about 10 feet above the deck and 26 feet above the water-line, and have very great train.

The 5-inch R. F. G. are mounted in the superstructures in such a way that four of them can fire right ahead, five on either beam and four right astern.

This cruiser is to be completed by January 1, 1893.

TORPEDO-VESSEL No. 1.

(Page 7, No. IX.)

Proposals were to have been opened on February 11 of this year, but none were received.

TORPEDO-BOAT No. 2.

Two proposals were received on December 20, 1890, to build this boat, but the Department did not accept either of them.

New plans were prepared and a re-advertisement issued on June 19 for proposals, which are to be opened on the 26th day of August, 1891. The requirements are for a sea-going torpedo-boat of about, but not less than, 120 tons displacement, to make on trial not less than an average of 24 knots per hour, maintained successfully for two consecutive hours.

Said vessel to be completed within twelve months from the date of the contract.

TUGBOATS.

The contracts for building three steel tugs were awarded on December 20, 1890, to Mr. Harrison Loring, of Boston.

They are to have the following dimensions: Length, 102.5 feet; beam, 21 feet; draught, 8.5 feet; displacement, about 190 tons.

VESSELS BUILDING.

The monitors *Puritan*, *Miantonomoh*, *Amphitrite*, *Monadnock*, and *Terror* are in various stages of construction and their completion depends now on the delivery of their armor and heavy guns. This may also be said of the *Maine* and *Texas* and all other armored vessels on the new programme.

Work is progressing on cruisers 7, 8, 9, 10, and 11, and on gunboats 5 and 6. Numbers 7 and 8 have been named *Cincinnati* and *Raleigh*.

VESSELS LAUNCHED.

MAINE.

Armored cruiser of 6,648 tons (page 298, No. VII) was launched at the New York navy-yard on November 18, 1890. The rig of this vessel has been changed and she is now to have three military masts with fore-and-aft sails.

MONTEREY.

Coast-defense armor-clad (page 331, No. VIII, and page 10, No. IX), was launched at the Union Iron Works, San Francisco, on April 28, 1891.

BENNINGTON.

Partially protected cruiser of 1,720 tons (page 300, No. VII), was launched at the shipbuilding yard of N. F. Palmer, jr., & Co., Chester, Pa., on June 3, 1890. (See Steam trials.)

STEAM TRIALS.

PHILADELPHIA.

First-class protected cruiser, of 4,325 tons (page 299, No. VII), had a very satisfactory full-power trial of her machinery June 25, 1890, off the south coast of Long Island.

A 40-mile course was carefully measured and marked by range beacons, and observations of current, wind, etc., were taken by a number of observers.

Two runs over this course gave the following mean results: Speed, 19.678 knots; I. H. P., 8,315; revolutions, 119.6; vacuum, 24.5 inches; steam pressure, 159.8 pounds; air pressure, 1.49 inches; coal per I. H. P., per hour, 2.99 pounds.

SAN FRANCISCO—NEWARK.

First-class protected cruisers of 4,083 tons (page 239, No. VI, and page 299, No. VII), have both passed their trials successfully and been accepted by the Government.

The *San Francisco's* trial took place in Santa Barbara Channel, off the coast of California, on August 27, 1890, and, as in the case of the *Philadelphia*, every precaution was taken to prevent error in the estimate of speed.

Two runs were made over a 40-mile course, with the following mean results: Speed, 19.663 knots; I. H. P', 9,913; vacuum, 25.9 inches; revolutions, 124.8; steam pressure, 135.3 pounds; air pressure, 2.02 inches.

A slight allowance had been made for unavoidable accidents which were not due to any fault of the engines or boilers, but these allowances were not admitted by the Department, and the vessel was accepted with an official speed of 19.524 knots.

The machinery trials of the *Newark* were for horse-power alone, the contract conditions being that the collective I. H. P. developed by the engines should be 8,500, maintained during four consecutive hours.

The first two attempts were unsuccessful, owing to the breaking of two bolts which secure the cap of the radius link of the low-pressure valve gear, but these bolts having been replaced by larger ones, a trial on December 22, 1890, gave the following very satisfactory results: Total I. H. P., 8,868.6; revolutions, 127; steam pressure, 161.9 pounds; vacuum, 25.8 inches; air pressure, 2.23 inches; coal per I. H. P., per hour, 2.23 pounds.

The estimated speed of the ship (allowing 18 per cent. slip) was 19¼ knots.

CONCORD—BENNINGTON.

These cruisers are reproductions of the *Yorktown* (page 333, No. VIII) in both hull and machinery, but the requirements were that their engines should develop 3,400 I. H. P. instead of 3,000, as in the case of their predecessor.

The only important modification of the *Yorktown's* plans, made for › later vessels, was the substitution of the closed ash-pit system of ced draft, for the closed fire-room system.

The *Concord* commenced her official trials on November 20, 1890, but s unsuccessful owing to some trouble with the feed pump of forward ler, and to a slight leakage in the ash pits.

Another attempt was made on January 13, 1891, which gave the fol- ring creditable mean results during a run of 4¾ hours: steam pressure, 164.3 pounds; vacuum, 24 inches; revolutions, 152; air pressure, 2.29 inches; coal consumption per I. H. P. per hour, 2.76 pounds; I. H. P., 3,404.5.

The speed was not officially taken, but observations of points passed gave an average of about 17 knots.

The *Bennington* was given trials in March of this year, with the following average results: Total I. H. P., 3,312; vacuum, 23.7 inches; revolutions, 150; air pressure, 1.99 inches; coal per hour, per I. H. P., 2.91 pounds.

The pitch of her propeller blades having been altered, another trial took place on April 2, which gave satisfaction: Mean I. H. P. of both main engines and all auxiliaries, 3,436.1; steam pressure, 166 pounds; vacuum, 23.8 inches; revolutions, 151; air pressure, 2.45 inches; coal per hour, per I. H. P., 2.6 pounds.

VESSELS LOST OR STRUCK FROM THE LIST.

Galena, wooden corvette, went ashore off Gay Head in March, 1891; to be sold.

Triana, *Nina*, tugs; wrecked in March, 1891.
Juniata, wooden corvette; sold in March, 1891.
Quinnebaug, wooden corvette; sold in March, 1891.
Pilgrim, tug; sold in March, 1891.
Saugus, monitor; sold in March, 1891.
Rescue, tug; sold in March, 1891.
Brooklyn, wooden frigate; sold in March, 1891.
Ossipee, wooden corvette; sold in March, 1891.
Speedwell, tug; to be sold.

ENGLAND.

The shipbuilding programme embodied in the Naval-Defense Act of 1889 was framed on the calculation that in 1894 the British fleet should be equal in fighting power to a combination of the forces of any two foreign powers, and the First Lord of the Admiralty has informed Parliament that the progress of new ships during the last two years has been so rapid that the relative position of the English navy as regards new construction, compared with that of foreign navies, has much improved, and that for this reason the Admiralty do not propose to add to the number of battle ships building.

The net estimated expenditure on the Navy for the year 1891–'92 is $89,201,000.

NEW CONSTRUCTION.

The number of vessels to be built under the Naval-Defense Act was 70, of an estimated displacement of 316,000 tons and carrying 540 guns, exclusive of machine and other guns of small calibre. All of these ships, with their armament and equipment, were to be completed and ready for commission before the 1st of April, 1894. With the single exception of one contract-built ship, whose progress has been slow, there is every reason to believe that the remaining 69 will, with their armament and reserve guns, be finished before the date named.—(Statement of First Lord of the Admiralty.)

VESSELS PROPOSED OR LAID DOWN.

BATTLE SHIPS.

The *Barfleur* and *Centurion* (page 334, No. VIII, and page 13, No. IX) are still called second-class battle ships on the Navy Lists, but they are to displace 10,500 tons and be more powerful than many of the older vessels that are rated as first class.

The keel of the *Barfleur* was laid at the Chatham dockyard in July, 1890, and that of the *Centurion* at Portsmouth in March, 1891.

The following details concerning them are taken from an official return:

Armament.—Four 10-inch 29-ton B. L., ten 4.7-inch R. F. G., seventeen 6-pounder and 3-pounder R. F. G., and seven torpedo-tubes (five above water and two submerged).

The 10-inch guns are mounted in pairs in armored barbettes which extend down to the steel protective deck at the top of the armor belt. These guns can be worked entirely by manual power, but, in addition, steam-power will be supplied for the training of the guns and supply of ammunition.

Protection.—A belt of armor, having a maximum thickness of 12 inches, extends over 200 feet amidships, and is completed by armored bulkheads, with a steel deck from 2 to 2½ inches in thickness at the top of the belt. Forward and abaft the armor belt a strong under-water deck completes the protection to the bow and stern. Above the thick belt the broadside will be protected to a height of 9½ feet above water by steel armor and wood backing equivalent to a total thickness of 4 inches of steel. Screen bulkheads, similarly armored, complete the protection to the sides of the barbettes.

The barbette armor has a maximum thickness of 9 inches.

The guns forming the auxiliary armament and their crews are also well protected, either by fixed casemates or by strong shields revolving with the mountings.

Estimated speed: With forced draft, 18 to 18½ knots; with natural draft, 17 knots. Coal supply at designed load draught, 750 tons.

These ships, like the new first-class battle-ships, will have a high free-board throughout their length, with a flush upper deck. The heavy guns forward are carried at a height of 25 feet above water and those aft a trifle lower.

The increase in size of these second-class battle-ships has been approved by the Admiralty after very full consideration, and is associated with the following advantages:

(1) Wood and copper sheathing on the bottoms, adapting the vessels for employment on distant services, where docking facilities may not be available.

(2) An increase in the weight of armament.

(3) Improved protection, in the form of casemates to the guns in the auxiliary armament.

(4) Larger and heavier boilers, giving a higher development of power for continuous sea service.

(5) The limitation of extreme draught when fully laden to 26 feet.

If these vessels are completed without further demands being made upon them for additional weights to be carried in connection with the armament or equipment, they will be capable of carrying 50 per cent. more coal than has been named above, and bunker space sufficient to carry this full supply has been provided.

As illustrating the speed at which war ships are now built in England it may be noted that 200 tons of material were built into the *Centurion* during the first week after she was laid down.

FIRST-CLASS PROTECTED CRUISERS.

All of the *Edgar* class (page 334, No. VIII, and page 14, No. IX) are in course of construction and three of them have been launched.

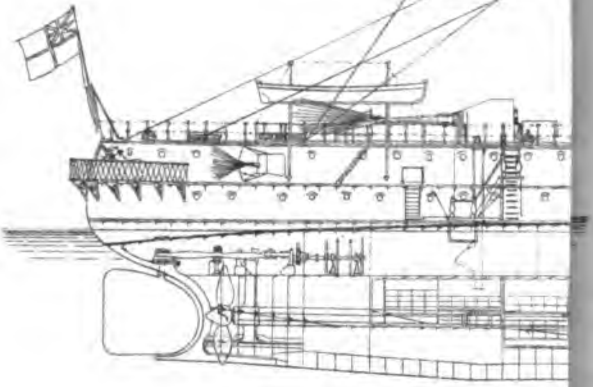
Eight of the second-class cruisers (*Apollo* type) have had their displacement increased to 4,360 tons and therefore now rank as first-class protected cruisers.

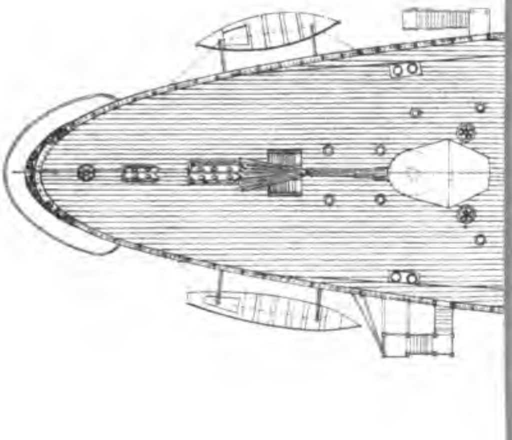
The armament of these vessels will consist of two 6-inch and eight 4.7-inch R. F. G., nine 6 and 3-pounder R. F. G., and four torpedo-tubes.

The thickness of protective deck and protection to the machinery, as well as the coal supply to be carried at the designed load draught, are identical with those of the vessels of the *Apollo* class, the essential change in the new ships being that they are of high freeboard throughout the length, with a flush upper deck, instead of having a poop, forecastle, and waist.

The whole of the broadside armament is carried on the upper deck in the *Astrea* class at about 8 feet greater height above water than in the *Apollo* class. This increase in dimensions combined with higher freeboard will greatly facilitate the continuous maintenance of a high rate of speed in a seaway. They are to be wood-sheathed and coppered.

The names of these vessels are *Charybdis*, *Forte*, *Flora*, *Fox*, *Astrea*, *Bonaventure*, *Hermione*, and *Cambrian*. They are all in course of construction or about to be laid down.





SECOND-CLASS PROTECTED CRUISERS.

All of the remaining twenty-one of this class (page 334, No. VIII, and page 14, No. IX) have been laid down and seventeen of them have been launched. (See Vessels Launched.)

TORPEDO VESSELS.

Work on the *Antelope*, *Circe*, *Hebe*, *Leda*, and *Alarm* (page 335, No. VIII, and page 15, No. IX) has been delayed, owing to the fact that the contracts for their machinery were not given out by the Admiralty until exhaustive trials had been made with the *Sharpshooter* class.

As a result of these trials it has been finally decided by the authorities to increase the displacement of the new torpedo vessels from 735 to 810 tons and make them structurally stronger.

Their engines and boilers, which are stronger and heavier than those of their predecessors, will only be required to develop 2,500 H. P. with natural draft, and 3,500 with forced draft, which powers are calculated to give speeds of 17.75 and 19.25 knots, respectively.

It is probable that they will all be given fore-and-aft bridges, as the *Sandfly* when crossing the Bay of Biscay was repeatedly washed down by the seas, and communication with the forward bridge was both difficult and dangerous. The *Speedwell*, *Salamander*, *Shelldrake*, and *Skipjack* have already been fitted in this manner.

VESSELS LAUNCHED.

ROYAL SOVEREIGN—EMPRESS OF INDIA.

Battle-ships of 14,150 tons displacement (pages 87, 97, and 334, No. VIII, and page 13, No. IX), have been launched; the former at Portsmouth, February 26, and the latter at Pembroke, May 7, 1891.

Both of these great armor-clads have been constructed with remarkable rapidity.

The *Royal Sovereign* was launched within 17 months after the laying of her keel. During this time 7,200 tons of the total weight of the hull (9,640 tons) was worked in, all the armor being on except five or six plates of the after barbette.

The *Empress of India* (then known as the *Renown*) was commenced in July, 1889.

BLENHEIM.

Launched from the yard of the Thames Ironworks and Shipbuilding Company, Blackwall, on July 5, 1890.

This 9,000-ton cruiser and her sister ship, the *Blake*, have been hitherto classed as "protected," but certain modifications that have been made in their designs, now entitle them to rank as armored cruisers.

It was at first intended to concentrate all armor on the protective deck and conning tower, but the destructive effect of rapid gun fire has shown that all possible protection should be given to gun crews, and it has been obtained in these ships by placing some of the guns in armored casemates and covering the others with heavy shields.

Some particulars concerning these vessels are given in No. VII, page 301, and the following description will show recent improvements and modifications:

Armament.—Two 9.2-inch 24-ton B. L. in bow and stern in armored towers; ten 6-inch R. F. G., six on the spar deck and four on main deck in casemates; sixteen 3-pounder R. F. G., seven Nordenfeldt machine guns, and four 14-inch Whitehead torpedo-tubes.

Protection.—Curved steel protective deck 18 inches above water-line amidships to 6½ feet below it at sides, and 3 to 6 inches thick. The top of machinery is above this deck and has 8-inch steel protection.

Casemates of maindeck guns have 6-inch steel on outboard sides and 2 inches inboard; ammunition tubes and tubes from conning tower, 8 inches; conning tower, 12 inches.

Motive power.—Four vertical triple-expansion engines in four water-tight compartments, estimated to give 20,000 I. H. P. and 22 knots speed.

Six double-ended boilers, arranged three abreast, in two fire-rooms.

EDGAR—ROYAL ARTHUR—HAWKE.

First-class protected cruisers of 7,500 tons (page 334, No. VIII, and page 14, No. IX), have been launched; the *Edgar*, at Devonport, in November, 1890, the *Royal Arthur*, at Portsmouth, February 26, and the *Hawke*, at Chatham, March 11, 1891.

The Admiralty have decided to modify the original designs of the *Royal Arthur* and *Crescent* and give them a long forecastle extending about 110 feet from the bow, and increasing the height of freeboard forward by 7½ feet. Upon this forecastle, at a height of 25½ feet above water, two 6-inch R. F. G. are to be mounted as bow chasers, in place of the single 9.2-inch B. L. carried forward on the upper deck in the other first-class cruisers.

All of the 6-inch breech-loaders on these ships will probably be replaced by rapid-fire guns.

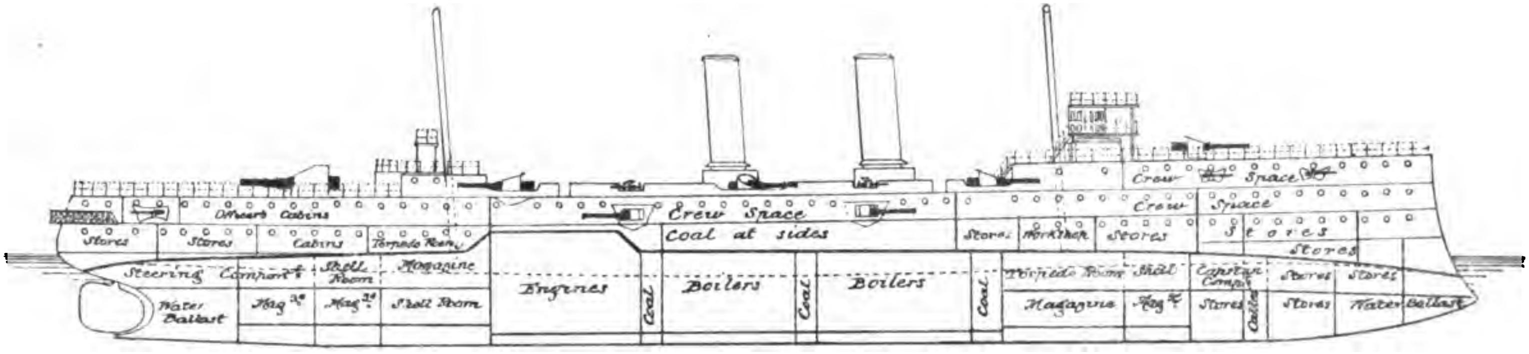
ANDROMACHE—MELAMPUS—NAIAD—PIQUE—SIRIUS—SYBILLE—TERPSICHORE—THETIS—TRIBUNE—APOLLO—SPARTAN—INDEFATIGABLE—RAINBOW—SAPPHO—INTREPID—BRILLIANT,

Second-class cruisers of the *Apollo* (improved *Medea*) class, have been launched since June 1, 1890. (See Steam trials, *Latona.*)

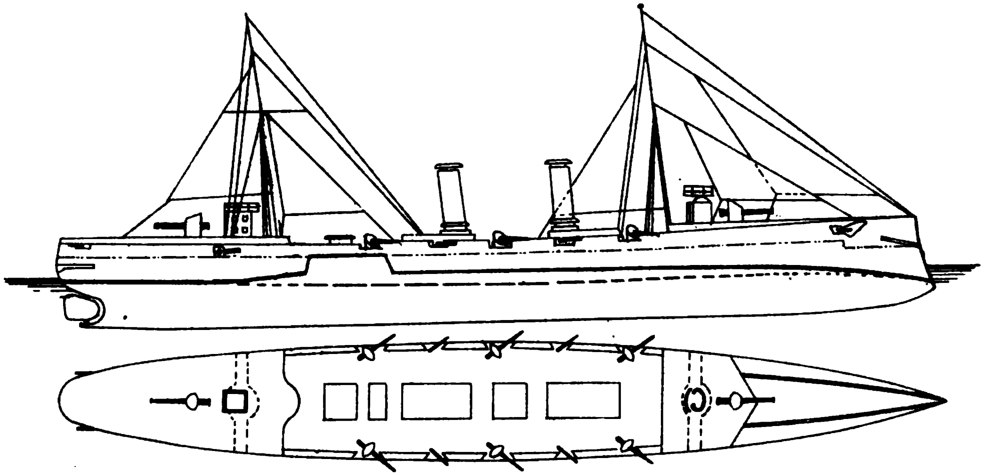
PALLAS—PEARL—PHILOMEL—PHŒBE,

Second-class protected cruisers of 2,575 tons, mentioned on page 335, No. VIII, were launched during the months of June, July, and August, 1890.

ROYAL ARTHUR



H. M. S. "SYBILLE."



These vessels are similar to the *Medea* class, but it is thought that their batteries of eight 4.7-inch R. F. G., instead of six 6-inch B. L., will prove more efficient. (See Steam trials.)

BELLONA,

Third-class, partially protected cruiser (page 302, No. VII, and page 15, No. IX), was launched from the shipbuilding yard of Messrs. Hawthorne, Leslie & Co., Newcastle-upon-Tyne, August 29, 1890. (See Steam trials.)

PLASSY—ASSAYE,

Torpedo vessels of the *Sharpshooter* type (page 303, No. VII, and page 336, No. VIII), were launched by Messrs. Armstrong, Mitchell & Co., at their Elswick yard, in July, 1890, and February, 1891.

They are intended for service in India. (See Steam trials.)

ASP,

A steel water-tank, fire-float, and tug vessel, built to order of the Admiralty, was launched at Blackwell in October, 1890, and delivered at Sheerness in January, 1891.

Besides being used as a tug, the *Asp* will carry 100 tons of fresh water, and a powerful fire engine, which will discharge water to the height of 100 feet at the rate of 200 tons an hour. Her dimensions are: Length, 115 feet; beam, 21 feet; depth, 10 feet.

The triple-expansion engines are of 300 I. H. P., and they have successfully passed their trials.

It is understood that this is the first of a number of vessels of this type which it is the intention of the Government to build.

STEAM TRIALS.

With regard to the trials of British war ships Lord George Hamilton informed the House of Commons on June 17, 1891, that the Admiralty had no intention of abandoning altogether the measured-mile trial, it being valuable as a test of the speed of English vessels compared with that of vessels of foreign nations. But they wished it to be understood that the trial by measured mile was only one test of a particular character, and that the real test of a vessel was only to be made by passage under steam for a considerable time in a seaway. It was perfectly true that considerable difficulty had been experienced in the past in trying some of their ships at high speed under forced draft, and that the Admiralty had been compelled to order that there should not in future be any trial under an extreme application of forced draft.

All those difficulties had arisen through one cause, that the ratio of boiler power was not sufficient or equal to the engine power.

He was glad, however, to be able to say that all the vessels building under the Naval-Defense Act would have larger boilers, and that the *maximum* power at the measured mile under forced draft would be limited to a certain point.

The Admiralty have amended the regulations governing the quarterly passage trials of ships of war (page 366, No. VIII) as follows: In order to insure that the machinery is kept in efficient order and to give opportunities of training the engine-room complement in working the engines at high speed, a trial is to be made once a quarter. This trial is to consist of a passage of not less than 24 hours' duration, which is to be run whenever circumstances will permit, with the engines working at from one-half to two-thirds of their specified natural-draft power.

The specified natural-draft power can usually be obtained with an air pressure not exceeding one-half inch of water, and this is to be considered the full power for continuous steaming at sea. The boilers and engines are not to be forced beyond this except in cases of emergency. During each passage trial the engines are to be run for a period of 4 hours at their highest speed with natural-draft, but the horse-power developed is not to exceed the specified natural-draft power.

In ships with closed fire rooms the air pressure during this 4 hours' run should not exceed one-half inch of water.

The rate of speed at which ordinary passages are to be made is left to the discretion of the commander-in-chief and senior officers, who will decide after taking into consideration the nature of the service which has to be performed.

The commander-in-chief will order a full power trial of the machinery in any case in which he may consider it desirable that such a trial should be made. Deck hands are not to be employed to assist the coal-heavers when the engines are running at full speed unless the coal has been worked so far back from the bunker doors as to render it absolutely necessary to do so.

The full-speed steam trial of the Mediterranean squadron took place on June 13, 1890, with the following results:

Name of vessel.	Class.	Displacement.	Average speed during a five-hour run.
			Knots.
Australia	Armored cruiser	5,600	16.5
Benbow	Battle ship	10,600	15.5
Victoria	....do	10,470	15.
Dreadnaught	....do	10,820	14.
Phæton	Partially protected cruiser	4,300	14.
Colossus	Battle ship	9,420	13.

The above trial does not do the *Phæton* justice, for in Septeml r, 1890, during her quarterly passage steam trial she made an averag of 15 knots for 490 miles, and 16 knots during the 4 hours at full spee

Another trial of the Mediterranean squadron took place on May 25 of this year. During a 4-hour run the battle ships made an average of 15 knots with not more than 7,500 I. H. P. (the limit). The *Camperdown* proved herself to be the best steamer, the next in order of merit being the *Anson*, *Howe*, and *Rodney*.

NILE.

Battle ship of 11,940 tons (page 305, No. VII) concluded her machinery trials in July, 1890.

The engines were contracted to develop 12,000 horse-power under forced draft, and 7,500 under natural draft, and were expected to indicate 4,750 on a continuous sea-going run of 96 hours with open fire rooms. Under these conditions the ship was expected to realize a speed of 17 knots, 16 knots, and 13.75 knots, respectively.

A 4-hour run was first made with open fire rooms, during which the mean collective horse-power developed was 9,074 and the speed about 14.5 knots. Two days afterwards the forced-draft trial took place. It lasted four hours, during which time the mean I. H. P. obtained was 12,102 with 96 revolutions. Steam pressure, 132.8 pounds; vacuum, 26.2 inches; air pressure, 1.82 inches.

A couple of runs over the measured mile showed a mean speed of 16.88 knots, while subsequent distance measurements gave 17 knots sea speed.

It will be seen from the above that the contracted I. H. P. was easily exceeded, but without giving any corresponding increase in the vessel's speed.

ALEXANDRA.

Battle ship of 9,490 tons, completed in 1877, has had a thorough overhaul and repair at a cost of about $400,000.

Her trial, which took place in November, 1890, was of a very satisfatory character, giving a speed of 15 knots over the measured mile with 8,000 I. H. P.

ANSON.

(Battle ship of 10,650 tons, page 250, No. VI.)

The shafts of this vessel were found to be badly out of line last September, and the bearings were in consequence given extensive repairs.

A trial in November gave the following results: Steam pressure, 90 pounds; revolutions, 91.7; air pressure .5 in.; I. H. P. 6,459; speed, 15.8 knots.

ACHILLES.

A broadside battle ship, built in 1864, has had her old boilers replaced by others of an equally obsolete type, which can only withstand a pressure of from 25 to 30 pounds.

This is due to the fact that the ship is supplied with simple engines of an old pattern, originally built in 1864.

A trial which took place on January 21 was not very successful (only 4,750 H. P. being obtained), but the vessel was accepted without further experiments.

SUPERB.

This battle ship (9,170 tons) was purchased from the Turkish Government in 1878.

Since that time she has been almost reconstructed, having been supplied with new engines and boilers and provided with a new armament of rapid-fire guns.

Like the other ships of her class, she was formerly square-rigged, but she is now jury-rigged to carry steadying sails, and has military tops on the fore and mizzen, while the main is a derrick mast for hoisting and signaling purposes.

Her trials took place in January and February of this year and finally terminated satisfactorily. The engines developed 6,157 horse power with natural draft, and gave an average speed of 13.5 knots.

THUNDERER.

An armor-clad of 9,330 tons, built in 1876, has received a new battery of modern guns and a new set of engines.

An 8-hour natural draft trial which took place in January, 1891, gave an average of 5,912 I. H. P., with 125 pounds steam pressure, 28.9 inches vacuum, and .44-inch air pressure (5,500 H. P. was required by the contract).

Although no official rates of speed were taken, in consequence of the condition of the ship's bottom, the average of two runs on the measured mile was 13.923 knots.

The engines were contracted to develop 7,000 I. H. P. under forced draft, but they were accepted without further tests in consequence of their having more than satisfied the conditions with natural draft.

The *Devastation*, sister ship to the *Thunderer*, is undergoing a similar transformation, and the *Rupert*, *Alexandra*, and *Superb* are completed for service. Thus, five powerful armor-clads, which some authorities have classed as obsolete, are practically modernized and returned to duty on the effective list of the British fleet.

VULCAN.

Torpedo-depot-ship (page 303, No. VII, and page 335, No. VIII) commenced her machinery trials on April 21, 1891, when a preliminary ru gave 10,250 horse power (maximum) and about 18½ knots speed wit natural draft.

Equally satisfactory results were obtained on April 24, when the ful power cantractor's trial at natural draft took place.

The mean I. H. P. during eight consecutive hours was 8,166, and fou runs over the measured mile gave a mean speed of 18.54 knots; stea pressure, 146 pounds; vacuum, 28.7 inches; revolutions, 88.3; air pressure, .457 inch; coal consumption per I. H. P., per hour, 2.2 pounds.

The *Vulcan's* armament consists of four torpedo-tubes, two above and two under water, and twenty rapid-fire guns. She also carries six torpedo boats, two countermining barges, and a steam pinnace, which are to be hoisted in and out by two immense cranes or davits worked by hydraulic machinery.

These cranes are 65 feet high, with an overhang or rake of 38 feet, and each weighs 27 tons. In order to give them adequate support about 30 feet of their total height is within the vessel, passing down through the three decks to the bottom where it rests on a special steel casting. They have been subjected to two tests. The first test consisted in hoisting the full working load of 20 tons through a lift of 40 feet at the rate of 90 feet per minute, traversing it through the entire range at a speed of 45 feet per minute and then lowering.

The load was next increased to 25 tons and it is intended eventually to increase the weight to 40 tons, or double the ordinary working load, when the ship is further advanced, before the gear is accepted from the contractors.

Every part of the machinery successfully withstood the tests, the droop of the derricks being inconsiderable and the permanent set about 1 inch, but the bottom plates of the vessel are said to have been somewhat strained in the vicinity of the crane beds.

LATONA—TERPSICHORE—MELAMPUS.

(Second-class protected cruisers, page 334, No. VIII.)

The *Latona* being the first of her numerous class to be tried has been subjected by the authorities to a series of very thorough experiments with the object of determining her general efficiency.

These twenty-nine vessels were called "*improved Medeas*" on account of their having been given some 600 tons more displacement, which was expected to overcome the objections which had been urged against the *Medea* class, viz, cramped engine rooms and bunkers, entailing difficulty of working at full power, and consequent physical exhaustion of the engine-room staff, and also the difficulty of steaming at high speed against a sea.

These anticipations appear to have been fully realized and the Admiralty are said to be well satisfied with the *Latona's* performances, but it is evident that they consider a still further increase in size advisable, as they have given the last eight ships a displacement of 4,360 tons.

(See *Astrea* class above.)

On December 24, 1890, the *Latona* made the run from Barrow-in-Furness to Portsmouth at an average speed of 15 knots with 4,500 horse power.

Heavy weather was encountered on the way and great quantities of water were shipped, but the vessel is said to have behaved well.

On January 30, 1891, the mean results of four runs over the measured mile with natural draft (.44 inch air pressure) were 7,247 I. H. P. and 19.051 knots.

The ventilation was perfect and subsequent examination of the boilers showed no sign of strain.

A forced-draft trial on February 6 was brought to a premature conclusion in consequence of the hawse-bucklers leaking, but when the vessel's trim had been altered, the bow wave gave no further trouble and a trial on February 10 was very successful; four runs over the measured mile gave a mean speed of 20.115 knots, with 1¼ inches air pressure, 145 revolutions, and 9,438 I. H. P.

The above ordeal with forced draft was rendered practicable from the fact that not only have the boilers been increased in size relatively to the power to be developed by the engines, but with a view of lessening the risk of leaky tubes and of localizing any defect which might arise therefrom, each furnace in the three double-ended boilers has been made with its combustion chamber separate and distinct from the others, the rectangular partition between the ends of the boilers forming a water chamber.

It is reported that this type of boiler will be adopted in all new vessels built under the Naval Defense Act.

In order to give the *Latona* still further tests under all conditions of service, she was sent last April to the Mediterranean for a 6 weeks' cruise.

Vice-Admiral Hopkins, Controller of the Navy, and Rear-Admiral Morant took passage on board of her in order to judge for themselves as to her capabilities, and they are said to have submitted a favorable report to the Admiralty.

The run from England to Gibraltar was made at an average speed of about 15 knots, and 17 knots was obtained between Gibraltar and Malta. On the return voyage a speed of 12 knots was maintained throughout. Considerable vibration was developed at the rate of 15 knots, but it was not materially increased at 17.

Although described as a good sea boat the *Latona* is a wet ship when steaming fast and some difficulty was experienced with the hawse plugs, as on a former occasion.

The engines worked smoothly during the entire trip and no defects were developed.

The results of the *Terpsichore's* trials were not in all respects satisfactory.

Under natural draft, after the vessel had been under way for about 7¼ hours the tubes began to leak and a return to port was necessitated. During this run the engines were worked to a steam pressure of 140.2 pounds and developed 7,133 H. P. with 127 revolutions, giving a speed of 18.6 knots.

The next day the defects were repaired and a start made for a trial under forced draft. All went well for the first three hours, but then the tubes began to leak again so that on the completion of the fourth hour the trial had to be abandoned. On an examination being made it was discovered that not only had the tubes leaked, but the seam at the back end of the boiler had given out.

The pressure during this trial was 145 pounds; the I. H. P. 8,820 revolutions 137, speed 19.8 knots.

The *Melampus* had an eight-hour, natural-draft trial on June 12, during which the following average results were obtained: I. H. P., 7,656; revolutions, 135; steam pressure, 147 pounds; vacuum, 27½ inches.

As the bottom of the vessel was foul it was not deemed expedient to test her for speed on the measured mile, but the approximate result was a speed of 18 knots.

The most noticeable feature of this trial was excessive vibration, due it is said to the ship's being too light and being badly trimmed.

A four-hour forced draft trial gave 9,093 I. H. P. with 146.7 pounds steam, 26.5 inches vacuum, 140.5 revolutions, and 1.28 inches air pressure; approximate speed, 18.35 knots.

MELPOMENE.

This cruiser is the last of the *Medea* type (page 337, No. VIII, and page 20, No. IX) to be completed and tried.

The natural-draft commission trial of her engines took place in July, 1890, with the following satisfactory results: Steam, 133 pounds; vacuum, 24 inches; revolutions, 125; I. H. P., 6,087. An unlimited supply of steam for the horse-power required was at command, and the only unfavorable feature observed during the trial was the abnormal temperature of the engine room, owing to the very small space which intervenes between the lower portion of the protective deck and the tops of the cylinders and steam pipes, whereby the circulation of the heated air is obstructed.

Steps were taken to remedy this defect by forcing an increased volume of cold air into the down cast shafts and thereby increasing the velocity of air in the uptakes, but there is still some trouble with the ventilation, for when the ship arrived at Panama last winter thirty-nine of her crew were on the sick list, due, it is said, to defects in her internal arrangements.

When bound from St. Vincent to Montevideo on her voyage out the *Melpomene* was obliged to put into Bahia for coal, thus showing her steaming radius to be nearer 3,000 miles at 10 knots speed than 8,000, as designed.

PEARL—PALLAS—PHILOMEL.

The preliminary run of the *Pearl* took place on February 12, 1891, but was brought to a premature conclusion by the heating of her machinery.

On the 14th another trial under natural draft was more successful.

The average speed by patent log during 8 hours was 18.428 knots; steam pressure, 149 pounds; air pressure, 0.34 inch; revolutions, 144; I. H. P., 5,077. A forced-draft trial on February 20 also gave satisfaction, and the vessel has been accepted. The machinery worked remarkably well, causing but slight vibration; and notwithstanding the fact that the horse-power developed was 325 short of the 7,500 required by contract, a distance of 79¼ miles was run in 4 hours, an average of 19.8 knots an hour.

The bow wave did not interfere with the hawse pipes as in the case of the *Latona*, but the top of it found its way on board over the rail, just forward of the smokepipes.

The air pressure was limited to 1.75 inches.

The *Pallas* also had successful trials in February, and has been accepted.

During a run of 8 hours under natural draft she developed a mean of 555 H. P. more than was stipulated for, with an air pressure of only two-tenths of an inch.

The forced-draft trial gave a mean speed of 19 knots with 7,317 I. H. P. during a 4-hour run. Air pressure, 1½ inches; vacuum, 27.5 inches.

An 8-hour natural-draft trial of the *Philomel* gave the following mean results: Steam pressure, 149 pounds; revolutions, 139; air pressure, .35 inch; vacuum, 27.3 inches; I. H. P., 4,945; speed, 16.25 knots.

Her forced-draft trial was also very satisfactory, as not only was the contracted horse-power considerably exceeded with a modified air pressure, but the vessel realized the highly creditable average speed of 19.5 knots during the 4-hour run.

Data of trial: Steam, 155 pounds; air pressure, 1.28 inches; revolutions, 163; vacuum, 26.2 inches; I. H. P., 7,735.

The vessel was brought down to commissioning trim by water ballast, of which no less than 300 tons was contained in the double bottoms. Under these conditions the bow wave was scarcely noticeable.

KATOOMBA—WALLAROO—TAURANGA—RINGAROOMA - MILDURA.

Of the five protected cruisers intended for service in Australia (page 16, No. IX) the *Katoomba* was the first to be tried, and her experiences have been somewhat unfortunate.

During a trial of her machinery in September, 1890, what appears to have been a repetition of the *Barracouta* disaster, took place; flames burst from the furnaces and severely injured a number of men. (The primary cause of both these accidents is now supposed to have been leaky tubes.)

Another trial took place in November, during which she ran for 8 hours under natural draft, and developed a mean of 4,528 horse-power, just above the maximum stipulated from the contractors. This was quite satisfactory, and the trial was considered to be a success until a subsequent examination of the boiler tubes showed them to be in a leaking condition. A 3 hour commission trial, which took place in April of this year, gave good results. Engines and boilers worked well, and 18 knots was obtained with natural draft.

Further experiments have been made with the *Katoomba* to decide the value of certain metallic shaft bearings. Lignum-vitæ having been found to wear rapidly has been discarded, and experiments are being made with different substitutes. In this case no success was met with, for after a series of dock trials, equal to a thousand miles' run, the bearings were found to have worn three-sixteenths of an inch.

The *Wallaroo* had a very satisfactory natural-draft trial in January, 1891. The machinery worked smoothly and well during 8 hours, and developed 63 horse-power more than the 4,500 stipulated for. The boilers were as tight at the end of the 8 hours as when the trial began, the ferruling of the tubes appearing to have completely cured their tendency to leak. The mean results of the entire run were as follows: Steam in boilers, 145 pounds; vacuum, 28.3; revolutions, 148; air pressure in fire-rooms, .57 inch; collective I. H. P., 4,563.

The *Tauranga* and *Ringarooma* both made satisfactory trial trips in the Clyde during January of this year, and attained nearly 19 knots, but on arriving at Devonport important alterations were made in their boiler fittings, and the combustion chambers were at the same time divided off from each other and dampers fitted, in order to prevent any more repetitions of the *Barracouta* disaster.

The natural-draft commission trials of these vessels took place in March, and were considered satisfactory, although the results fell slightly below the contract power.

The *Tauranga* obtained 16.2 knots with 4,419 I. H. P., and the *Ringarooma* 16.9 knots with 4,478 I. H. P.

The *Ringarooma* was then given a 10 days' sea trial, which gave satisfaction. During a continuous run at full speed, under natural draft, for 24 hours the vessel averaged 16.7 knots while the average horse-power developed was 4,179. During the remaining period runs at various speeds were made which proved her to be an excellent sea boat.

The commissioned trials of the *Mildura* were interrupted by a number of accidents, but it is understood that she finally passed them successfully.

The vessels of this class were originally intended to develop 7,500 horse-power under forced draft, but the Admiralty have decided not to submit them to a trial that might permanently injure their boilers.

BARHAM—BLONDE—BARROSA—BLANCHE—BELLONA—BARRACOUTA.

Partially-protected cruisers; all of 1,580 tons displacement except the *Barham* and *Bellona*, which have 1,830 tons. (Page 302, No. VII, and page 15, No. IX.)

The *Barham* made a second attempt July 9, 1890, to complete the contractor's trials of her machinery. Since the last trial the supports to the thrust-block bearings had been stiffened and several feet added to the height of her smoke pipes.

The alterations answered their purpose admirably, but in other respects this trial proved a failure. During the third hour, when a speed of about 17 knots had been realized with an inch of air pressure in the fire rooms, and when the engines were exerting more than their contract power, the tubes of several of the boilers, began to leak, and the ship was obliged to return to port.

On July 24 a third trial took place, but after running 3½ hours the leakage was so great that the water totally disappeared from the glasses of a whole set of boilers, and it became necessary to extinguish the fires.

These mishaps rendered it necessary to take out a number of tubes to give freer circulation of water, and when this had been done the *Barham* at last terminated her trials successfully on February 17, 1891, and was accepted by the Admiralty.

An average speed of 17.348 knots was obtained with 1⅛ inches air pressure during an 8-hour run. Mean I. H. P. 3,614; steam pressure, 139 pounds; revolutions, 175½; vacuum, 26½ inches.

The *Blonde* had an 8-hour trial of machinery with natural draft on June 11, 1890. With half an inch air pressure in the fire rooms the following results were obtained: Maximum I. H. P., 2,087; mean I. H. P., 1,913; mean revolutions, 173.6; steam pressure, 137 pounds; vacuum, 26.1 in. There was a rough sea outside, but the vessel developed a speed of 15.3 knots.

A second natural-draft trial took place on July 25. The general results were reported as satisfactory, although after 6 hours' steaming her port boilers were leaking badly. The trial, however, was completed and a speed of 15.75 knots attained.

A third natural-draft trial took place on August 14. Time, 8 hours; no leakage of boilers. With ½ inch air pressure the following results were obtained: I. H. P., 1,822; revolutions, 170; speed, 15.25.

A forced draft trial, on August 19, gave 2,298 I. H. P.; and another, on August 21, gave 2,750 I. H. P. and 16.72 knots speed.

This concluded the series, and the vessel was accepted, although the required 3,000 I. H. P. had not been obtained.

No trouble was experienced with the *Barrosa's* boilers under service conditions during the maneuvers, but it was thought expedient to test their endurance under forced draft, and she was therefore taken out in September, 1890, for a 96-hour run with full power.

The trial was twice interrupted by fog, but as the vessel had been 72 hours under forced draft, and during that time had done excellent steaming with 1 inch pressure in the fire rooms, it was considered to be sufficiently conclusive.

Before starting, several rows of tubes had been removed from the boilers, and the alterations gave such satisfactory results that no leakage took place.

The *Blanche* had a satisfactory 4-hour forced-draft trial of her machinery early in June, 1890.

The following results were obtained with a mean air pressure of 1.4 inches and a steam pressure of 144 pounds. Vacuum, 25.5 inches; revolutions, 192; I. H. P., 2,809; speed, 16.4 knots.

Serious defects were afterwards discovered in the coverings of her propeller shafts, and her commissioned trials were thereby delayed until February 18, 1891, on which date she made 15 knots with 1,700 I. H. P. and .3-inch air pressure. No attempt was made to get higher results.

The *Bellona* is said to have obtained a mean speed of about 19 knots with 3,557 I. H. P.; but no reliable details concerning her trials have yet been received.

The defects discovered in the *Barracouta's* boilers after the accident of February 7, 1890, having been made good by the contractors, and dampers fitted which it was hoped would effectually prevent such an emission of flame into the fire room as occurred on that occasion, the Admiralty gave orders in November, 1890, to prepare the ship for a resumption of her steam trials.

The original requirements had been much modified, and it was now only stipulated that the machinery should develop 1,900 horse-power, with ½-inch air pressure.

Trials on December 19 and 23 were unsuccessful; but on January 9, 1891, a third attempt gave what were accepted as satisfactory results. Engines and boilers worked well during 8 hours, and developed 1,920 I. H. P. The speed was 15.4 knots with the tide and 14.2 against it.

SHARPSHOOTER—SANDFLY—SPEEDWELL—SKIPJACK—SPANKER—SEAGULL—GOSSAMER—BOOMERANG—KARRAKATTA—PLASSY.

All of these torpedo vessels are of the *Sharpshooter* type (735 tons) except the *Sandfly*, which has 200 tons less displacement.

The *Sharpshooter* was taken outside Plymouth breakwater on June 13, 1890, for a preliminary trial, to test new circulating gear which had been fitted in two of her boilers to prevent leaking of tubes under forced draft. The circumstances were such as had always caused this trouble on former trials, but an inspection made after this run showed that the experiment was undoubtedly a step in the right direction, there being no sign of leakage.

On September 28 an 8-hour full-speed trial was attempted, but in consequence of a break-down of the machinery it was postponed. The starboard low-pressure piston rod bent and other defects developed.

A successful natural-draft trial took place in October, during which the engines developed 3,010 I. H. P. and gave 16½ knots speed, and the vessel was accepted without any further attempts to obtain the maximum results required by her design.

The *Sandfly* had a natural draft trial early in July, 1890, which gave the following results: Steam pressure, 136.5 pounds; revolutions, 207; vacuum, 26.4 inch; I. H. P., 824; speed, 11.5 knots. Another trial which took place on July 19, gave 14 knots over the measured mile and the ship was at once prepared for foreign service.

When crossing the Bay of Biscay last November the *Sandfly* encountered a heavy gale, during which her seagoing qualities were severely tested. It is reported that she was continually under water, and that it was found necessary to throw overboard all the powder and stores.

The *Speedwell* had satisfactory speed and gun trials on July 15; 3,300 I. H. P. and 18 knots were obtained and the vessel accepted.

Special interest attached to the gun trials, as the *Speedwell* was the first of her class to undergo this ordeal. Fourteen rounds were fired from each 4.7-inch gun and four from each 3-pounder.

Experiments have been made with the shaft bearings of this vessel, to test the value of a new amalgamation of metals, which it was hoped would prove more durable than lignum-vitæ or any of the metals that have yet been substituted for it, but it has not proved a success.

The *Skipjack* had forced draft trials on September 17 and 18, 1890. An order had been given not to exceed 3,500 I. H. P., but she obtained 60 in excess and realized a speed of 19.75 knots; machinery worked smoothly and the boilers, with improved fittings and larger grate-surface, were said to be all that could be desired.

The above results were considered satisfactory by the Admiralty and they decided to accept the vessel without forcing her engines to develop any higher power.

The *Spanker* went out from Plymouth on October 17, for a three hour trial under forced draft. For the first 2½ hours all went well and 3,765 I. H. P. and 19 knots speed were obtained without difficulty, when the contractors determined to push the engines to 4,000 H. P. The attempt was made and 4,000 actually reached, when suddenly the tubes of the starboard after-boiler gave out and began leaking in an alarming manner. This appears to have caused a back draft as in the case of the *Barraconta*, but as effective measures had been taken to prevent flames entering the fire-room, no casualties occurred.

After returning to port it was found that the tubes of the other boilers had begun to leak, so that if the trial had continued the break-down would have been complete.

The *Seagull* having been greatly strengthened by extra stanchions and braces, had trials in the Fall of 1890 which proved unsuccessful, owing to the loss of one of her propeller blades.

Repairs were made and some of her boiler tubes removed, but a trial in June of this year failed to give good results. Tubes leaked, and the low pressure slide was broken because it was too thin to stand the strain.

More than usual interest was taken in the trials of the *Gossamer*, as her engines had been constructed by the Government at Sheerness Dockyard instead of being given out by contract, according to past custom.

Successful dock trials took place in December, 1890, the engines working smoothly without any hot bearings, and the boilers giving a plentiful supply of steam.

A natural draft trial in January, 1891, also gave good results, a mean of 2,618 H. P. being developed during an 8-hour run, with 133.3 pounds steam pressure and 228.6 revolutions.

The Admiralty were so well satisfied with the above performances that they accepted the vessel without subjecting her to a forced draft trial, and decided to build the machinery of a number of the new cruisers in Government workshops.

The *Boomerang* and *Karrakatta* (formerly *Whiting* and *Wizard*), after a number of unsatisfactory preliminary trials and consequent alterations in their machinery, have obtained good results as far as the power of their engines is concerned.

The *Boomerang* attained 2,612 I. H. P. with natural draft and 3,508 with forced draft, and the *Karrakatta* 2,580 and 3,840 under the same conditions.

This last vessel had several other trials during March and April of this year, which did not prove so successful, as the feed pumps worked irregularly and the boilers primed badly at times, but the defects were remedied and the ship finally accepted in May, 1891.

Examinations of the under-water fittings since the above trials have shown that the stern tubes and brackets are considerably worn, and the Admiralty have therefore directed that the shaft bearings of both vessels be relined with white metal of a special composition.

PLASSY.

Torpedo vessel, for service in India, went out for a natural-draft trial on July 24, 1890, but, after a 2 hours run, one of her propeller blades broke off and the trial was discontinued. Another attempt in May, 1891, was equally disastrous, for the vibration of the engines was so enormous that the steam pipes between the high-pressure and intermediate cylinders on both sides were cracked, and it was considered unsafe to continue the run.

SPARROW—LAPWING—RINGDOVE.

Gun vessels of 805 tons displacement (page 21, No. IX).

On June 4, 1890, the *Sparrow* had her full-power commission trials, which gave a mean speed of 12.5 knots during a 3 hour run.

The *Lapwing* had a successful natural-draft trial on July 29, and on August 4 a run under forced draft gave the following good results: Mean pressure, 138.5 pounds; vacuum, 24.9 inches; air pressure, .96 inch; revolutions, 185.2; I. H. P., 1,203; speed, 13.13 knots. A 96-hour full-speed trial was ordered by the Admiralty and attempted in October, but was not completed owing to fog and bad weather. The ship ran for 30 hours, making 11 knots against a moderate gale, and proving to be a capital sea boat.

The *Ringdove* was given a full-power trial in October, which gave a mean of 1,127 I. H. P. and 13 knots speed during 4 hours.

Both this vessel and her sister ship, the *Lapwing*, have had 2 inches cut off the blades of their propellers, in hopes of lessening vibration caused by the close proximity of the blades to the casting. This change has obtained the desired result, but it has caused a diminution of speed and the necessity for additional exertion in the fire rooms.

VESSELS LOST OR STRUCK FROM THE LIST.

Serpent, third class, partially protected cruiser, lost on the coast of Spain, November 10, 1890.

Foudroyant, to be sold.

Algiers (late Anson), ship; noneffective.

Defence, iron ship, armor-plated; noneffective.

Irresistible, depot-ship, Bermuda; to be sold.

Merlin, screw gunboat; to be sold.

Tyrian, screw gunboat; to be sold.

Valorous, special-service vessel; to be sold.

Victoria, ship; noneffective.

Forester, gunboat; to be sold.

Banterer, gunboat; to be sold.

Excellent and *Vernon*, gunnery training ships, worn out in service, crews transferred to quarters on shore.

Bustler, tug; to be sold.

FRANCE.

The Credits asked by the Minister of Marine for the general expenses of the Navy during 1891–'92 amounted to about $42,500,000, and after much discussion the appropriation was granted by the Chamber of Deputies and Senate, without amendment.

The principal arguments in favor of the expenditure were based on the ground that the French navy in 1895 would be much inferior to the combined forces of Italy, Germany, and Austria (the Triple Alliance) unless it were materially increased in the meantime.

As one result of the above discussion the Chamber proceeded to elect a Committee of 33 members, to which all naval questions will be submitted.

A supplementary estimate of $1,600,000, to be expended in new construction, was submitted by the Minister of Marine in March of this year, but at last accounts the vote on it had been deferred by the *Commission du Budget* until an explanation should be made of the great delay in building war ships already provided for.

In regard to future construction the Minister of Marine has thus outlined his policy:

> As soon as the three armor-clads provided for in the Budget of 1891 shall be in full course of construction, two others will be commenced, which are to be provided for in the Budget of 1892.
>
> A certain number of cruisers, torpedo vessels, and torpedo boats will be commenced at the same time in order to continually preserve the same proportion between different classes.

VESSELS PROPOSED OR LAID DOWN.

BATTLE SHIPS.

LAZARE CARNOT—CHARLES MARTEL—JAURÉGUIBERRY.

These three battle-ships (page 27, No. IX) have been laid down; the first two by the Government, at Toulon and Brest, and the third by the Forges et Chantiers de la Méditerranée, at La Seyne.

The following details concerning the *Carnot* and *Martel* have been recently published:

Armament.—Two 12-inch B. L. in closed revolving turrets on centre line in bow and stern, the forward gun being 26.2 feet, and the after gun 19.7 feet, above water; two 10.6-inch B. L. in closed turrets, one on each beam; eight 5.5-inch R. F. G., also in closed turrets, four on each side; about 20 R. F. G. of lighter calibre and 6 torpedo-tubes.

Protection.—Steel water-line belt of 17.7 inches maximum thickness; protective deck over vitals, 2.7 inches thick; 3.9-inch armor on the upper works forward; turrets for heavy guns, 14.6 inches; turrets for light guns, 3.9 inches.

Speed, 17 knots with natural draft, and 18 with forced draft.

Dimensions.—Length, 393.7 feet; beam, 71.1 feet; displacement about 11,900 tons.

The plans of the *Jauréguiberry* as approved by the Ministry have the following principal characteristics:

Armament.—Two 11.8-inch B. L. in closed turrets on axis of ship, one forward and one aft; two 10.6-inch B. L. in turrets at the sides but on a lower level; eight 5.5-inch R. F. G. in four closed turrets at each corner of a central battery; four 65-mm. and twelve 47-mm. R. F. G.; eight 37-mm. R. C., and six torpedo tubes.

Protection.—Water-line belt, complete, 10.8 to 17.7 inches thick; protective deck 2.7 inches; turrets for heavy guns 14.6 inches; turrets for light guns and armored cofferdam 3.9 inches.

Motive power.—Two triple-expansion engines, which will be supplied with steam by twenty-four tubular boilers of the d'Allest type.

Estimated horse power 13,275; speed with natural draft 17 knots.

The design in building these ships was to give the guns effective protection, to have heavy fore-and-aft fire, and to obtain good speed with an extended steaming radius.

These results were obtained by slightly increasing the displacement and by diminishing the calibre of the heavy guns and placing them in closed turrets. Better protection for the secondary battery was obtained by reducing the number of these guns and thus allowing more weight for armor.

The guns and turrets of the *Jauréguiberry* are to be worked by electricity, but hydraulic power will be used on board the other two ships.

Two battle ships are provided for in the new Budget; one is to be commenced at L'Orient in 1892, and the other will be given by contract to a private firm.

They will probably resemble their three immediate predecessors.

TRÉHOUART.—JEMMAPES.—VALMY—BOUVINES.

These armorclads (page 27, No. IX) have hitherto been classed as coast-defense vessels, but their plans have been revised and so modified as to change the type to which they belong. Their freeboard, forward and aft, has been increased, and to allow for the extra weight due to this alteration the heavy guns have been reduced in calibre from 13.4 to 11.8 inches.

CHASSELOUP-LOUBAT.—BUGEAUD.—FRIANT.

Protected cruisers, *Davout* type (page 27, No. IX), have been laid down at Cherbourg, Toulon, and Brest. They are to be larger and more formidable vessels than their prototype, as will appear from the following description:

Dimensions.—Length between perpendiculars 308 feet, 5 inches; extreme breadth 43 feet, 4 inches; extreme draught 20 feet, 9 inches, displacement 3,722 tons.

Armament.—Six 6.3-inch B. L., four 3.9-inch R. F. G., twenty 47 and 37 mm. R. F. G., and six torpedo tubes.

Protection.—Armored deck, complete, 1.2 inches to 3.1 inches thick; gun shields.

Motive power.—Engines of 9,000 I. H. P., to give 19.5 knots speed.

The new Budget provides that, in 1892, contracts shall be placed for the construction of one first-class cruiser, two second-class cruisers for foreign service, one third-class cruiser (type, *Forbin* modified), one transport or supply vessel for the fleet (to carry ten 59-foot torpedo boats), and two torpedo-vessels which are to have 850 tons displacement and be similar to the Italian *Partenope*.

VESSELS LAUNCHED.

DUPUY DE LÔME.

This armored cruiser (page 312, No. VII) was launched at Brest on October 27, 1890.

It is expected that she will be ready for trial by the end of 1891.

PHLÉGÉTON.

Armored gun vessel of the *Achéron* type, laid down in 1885, was launched on December 20, 1890.

She is the third of her class, and a fourth one, the *Styx*, is in course of construction.

It is reported that these vessels are overweighted with armor and that they roll badly in a seaway. The *Phlégéton* carries one 10.6-inch B. L. in a closed turret forward and one 5.5-inch aft. Thickness of armor belt, 6 to 8 inches; turret, 8 inches; displacement, 1,640 tons.

WATTIGNIES.

Third-class protected cruiser (page 341, No. VIII, and page 28, No. IX); was launched at Rochefort April 9, 1891.

This vessel is classed by the French as a "croiseur-torpilleur," and she will probably perform some of the duties of a torpedo vessel. Her armament consists of five 10-cm. R. F. G. (instead of 10-cm. B. L. as on the *Condor* class), six light R. F. G., and four torpedo tubes.

Protection.—A complete protective deck 1.6 inches thick is at level of water-line amidships and 3 feet below it at the sides; a belt of cellulose about 3 feet thick extends from the protective deck to 2.2 feet above the water-line.

Motive power.—Two horizontal triple-expansion engines, to give 4,000 H. P. and 18 knots speed. Steaming radius, 1,800 miles, at 12½ knots.

Dimensions.—Length, 232.9 feet; beam, 29.2 feet; depth, 20 feet; draught, 15.5 feet; displacement, 1,310 tons.

The total cost of this vessel has been $583,900, divided as follows: hull, $351,000; machinery, $203,900; artillery, $29,000.

MANCHE.

A wooden transport, described on page 260, No. V, was launched at Cherbourg on October 16, 1890.

LEVRIER.

Torpedo vessel (page 28, No. IX); was launched at L'Orient April 2, 1891.

ISLY.

First class protected cruiser of 4,160 tons, was launched at Brest on June 23, 1891.

STEAM TRIALS.

The following decisions of the Minister of Marine with regard to steam trials of war vessels were published in an official circular, dated July 21, 1890:

I. The arithmetical mean of the measured speeds in an even number of alternate runs will be taken.

(1) In protected ports where currents have little importance.

(2) In open ports (roadsteads) when a sufficient number of runs, under proper conditions, shall be made to compensate in a great measure the variations of the current.

To obtain this result it will be necessary to make at least six runs. At least one-third of these runs should be made before the current has reached its maximum if the others are made afterwards, or two-thirds may be made before the turn of the tide and one-third after it.

II. In open ports when it is not possible to make a sufficient number of runs, or when the conditions are such as to prevent the elimination of errors due to the current by employing the preceding method, the runs should be grouped three by three and the mean of each group taken, doubling the middle runs, then the arithmetical mean of the results so obtained.

These groups of three might be handled in several ways, but it is important not to give too great importance to any particular run and not to count any one run more than twice; so the following grouping will be used:

For 3 runs: 1 group $\frac{a+2b+c}{4}$.

For 5 runs: 2 groups $\frac{a+2b+c}{4}$, $\frac{c+2d+e}{4}$.

For 6 runs: 2 groups $\frac{a+2b+c}{4}$, $\frac{d+2e+f}{4}$.

For 7 runs: 3 groups $\frac{a+2b+c}{4}$, $\frac{c+2d+e}{4}$, $\frac{e+2f+g}{4}$.

A general order, dated March 6, 1891, establishes the method of estimating the power of the machinery of French warships as follows:

The unit of power employed will be exclusively the horse-power of 75 kilogrammetres per second.

No further use will be made of *nominal* H. P., and the employment of this unit should be abandoned in all technical and administrative documents.

As it is not possible for engines and boilers to sustain the maximum pressure to which they can be subjected under forced draft for any length of time, the *maximum power* of war vessels will hereafter be considered as that which can be furnished by the machinery during the 4-hour trial, and in view of this determination all future contracts will provide for an extreme test of this duration.

The *normal power* is that which can be sustained continuously without difficulty by both engines and boilers, and all future contracts will provide for a 24-hour trial under these conditions.

The proportion between the *normal* and *maximum* H. P. varies according to the type of boiler and the degree of importance given to forced draft. The requirements under both these conditions should therefore be defined in the specifications of new ships and machinery.

The powers to be adopted officially after the conclusion of the trials should be determined by the trial boards and be inscribed on the ship's papers.

Many accidents have occurred to the machinery of French warships during the last 12 months, which will probably lead, as in the English service, to an increase in the weight of boilers and engines.

When the torpedo vessels of the Mediterranean squadron made the run from Cherbourg to Toulon last August, "innumerable" accidents occurred. Their boilers were constantly giving out, and it became necessary at times for the battle ships to take them in tow.

MARCEAU—HOCHE,

Battle ships (page 258, No. VI.), have both been tried and accepted by the Government.

The preliminary natural-draft trial of the *Marceau* took place at Toulon in October, 1890, when a speed of 14.8 knots with 74 revolutions was attained, and the machinery worked perfectly.

A 4-hour forced-draft trial was afterwards run, during which the average speed was 16.4 knots and the I. H. P. 11,017.

The gun tests of this vessel have also been very thorough and satisfactory. Each of the 13.4-inch guns was fired seven times, twice with reduced, and five times with service charges, and very little injury resulted either to the superstructure or deck.

As to the personnel, it was found that the guns' crews in the secondary battery, directly below the turrets, could remain at their quarters without danger, but that it was not safe to expose men to the blast of heavy guns in the open on upper deck.

The *Hoche* terminated her trials successfully in January, 1891.

In the forced-draft trial the coal consumption was limited to 150 kilos per square metre of grate surface, but more than 11,000 I. H. P. was obtained, and a mean speed of 16 knots during two hours, the engines making 82 turns per minute.

With natural draft, the engines making 70 revolutions gave 14 knots during 6 consecutive hours.

This vessel differs from the other French battle ships in having low freeboard forward and aft, and it was therefore thought advisable to give her seagoing qualities a special test, and on January 15 she was taken outside of Brest Harbor for a 24-hour run.

During the first two hours, she made 15 knots with forced draft and for the remainder of the time an average of about 12.5 knots with 60 revolutions. At first the wind had only a force of 4, but on the return trip it freshened to 6 and the sea became rough. The *Hoche's* speed did not, however, fall below 12 knots at any time, and although waves frequently swept over her forecastle the water ran off quickly and the ship recovered herself with ease.

These tests seem to have proved her a good sea boat in ordinary weather, and it is reported that the authorities are satisfied on this point.

CÉCILE.

The final trials of this first-class protected cruiser (page 29, No. IX) commenced on July 1, 1890. Conforming to the contract they were made with all weights on board as in actual service. The first trial was made over the official base at Hyères. This base (measured course), 6.72 miles long, was run over six times during the trial. A fresh wind was blowing and the sea was rough, but, in spite of these unfavorable conditions, the mean speed for the six runs was 19.173 knots; I. H. P., 10,480; revolutions, 101; coal consumption, 140 kilos per hour per square metre of grate service (the contract permitted the consumption of 160 kilos); boiler pressure, 6.3 kilos per square centimetre; air pressure, 0.58 inch.

Engines worked perfectly and pressure easily maintained.

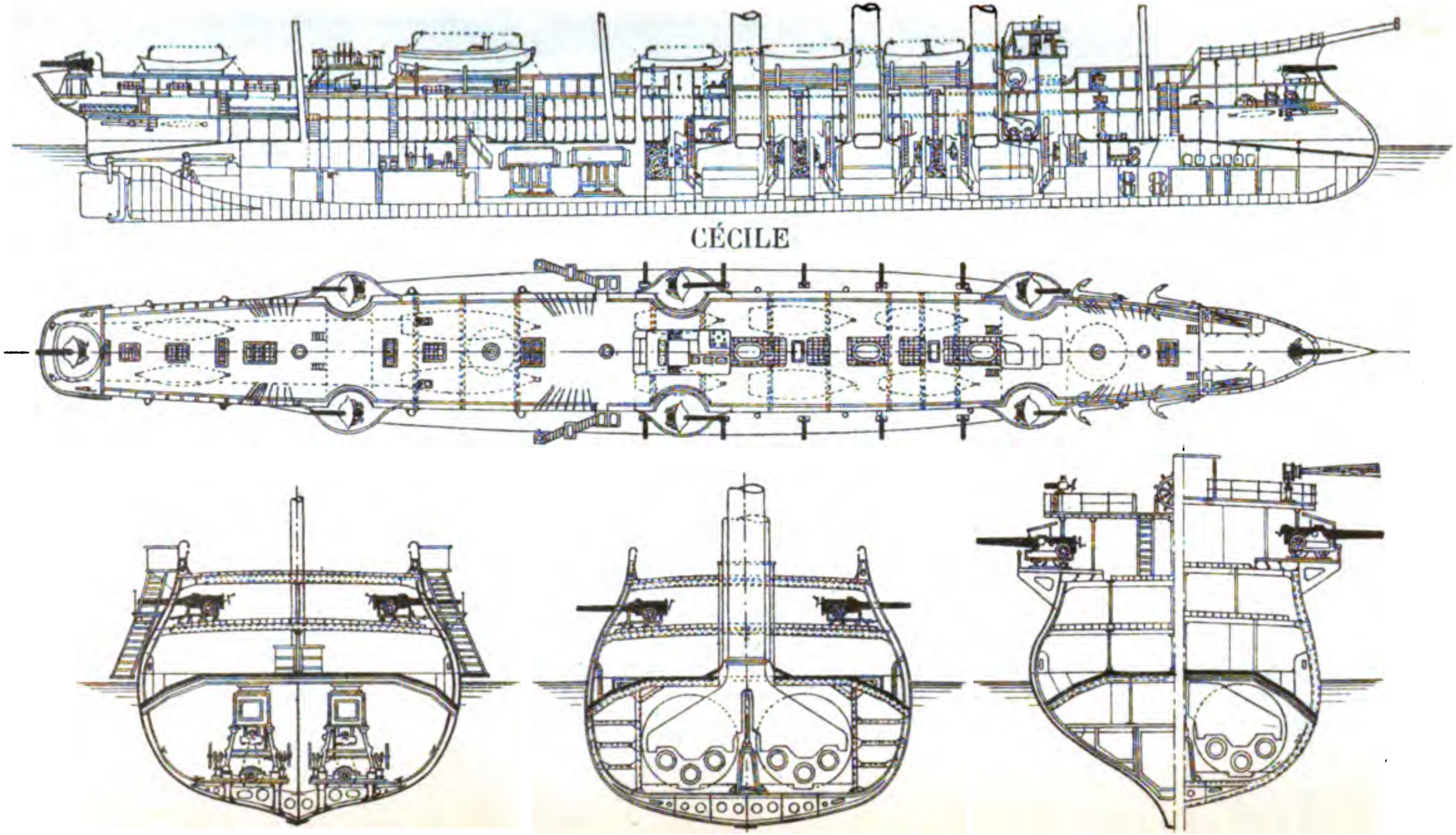
On July 5, the extreme trial (*essai à outrance*) took place, during which the machinery was forced to its maximum power. It took place over the measured course and lasted two hours. A mean speed of 19.436 knots and 10,680 I. H. P. was obtained.

In spite of the heavy strain on the machinery it worked smoothly and no signs of weakness appeared in any part.

The trial for coal consumption took place on July 23 and lasted 24 hours.

The result was a consumption of 1.95 pounds per horse-power, per hour for 6,595 I. H. P.

The speed during this trial was constantly maintained at 18 knots with no difficulty whatever, and as the run was made in open sea it shows that this cruiser can be depended upon for this rate in ordinary weather so long as the supply of coal holds out.



CÉCILE

Her manœuvring and gun trials were equally satisfactory, and it is therefore affirmed that the *Cécile* has finally satisfied all the demands of the programme as laid down by the Ministry.

TAGE.

First-class protected cruiser (page 29, No. IX), is said to have terminated her trials brilliantly, having maintained a speed of 19 knots during a 6-hour run.

FORBIN—TROUDE—SURCOUF—COËTLOGON—LALANDE.

Third-class protected cruisers of from 1,848 to 1,877 tons displacement (page 29, No. IX).

These vessels are called third-class cruisers, as their displacement is more than that usually allowed to torpedo-vessels; but, as they possess the distinguishing characteristic of great speed, they will probably be given all the duties of this latter class and prove very efficient if their machinery holds out.

(In this connection it may be noted that defects were discovered in the *Forbin's* machinery during December, 1890, which it was then reported would require several months to repair.)

The *Troude* finished her trials in December and gave great satisfaction.

According to the contract, the Société des Chantiers de la Gironde was to fulfill the following conditions:

(1) During a 2-hour forced-draft trial the speed should not fall below 19.5 knots.

(2) During a 12-hour trial at a mean speed of not less than 17 knots the coal consumption during the first 6 hours should not be more than 1.98 pounds per hour, per I. H. P.

(3) Finally during a 6-hour trial with about one-quarter of the total power of machinery, the consumption of coal should not exceed 2.2 pounds per hour, per I. H. P.

The following table gives detailed results of the three trials:

	Full power trial (2 hours) December 1, 1890.	Trial with reduced power (6 hours), December 9, 1890.	12-hour trial December 11, 1890.
Force of the wind	4	3	2
Mean number of revolutions per minute	133.4	85.05	108.74
Speed in knots	20.913	14.208	17.565
Total I. H. P. (not including about 16 H. P. absorbed by the steering and electric-lighting machinery)	6,247	1,591	3,393
Consumption of coal per hour, per I. H. P., pounds	2.8	2.12	1.93
Steaming radius in nautical miles with 287 tons of coal	765	2.658	1.621

The *Surcouf* had trials for coal consumption in July, 1890, with the following results:

Natural draft—1,800 I. H. P. and 15 knots speed. Coal consumption, 1.98 pounds per horse-power.

Forced draft—3,508 I. H. P and 17.3 knots speed. Coal consumption 1.86 pounds per horse-power.

On September 9 a full-power trial gave a speed of 20.51 knots, with 6,287 I. H. P., and 133 revolutions.

The preliminary trials of the *Coëtlogon*, which had been repeatedly interrupted by serious accidents to the machinery, were finally brought to a successful conclusion in March and April of this year. The forced-draft trial gave a mean speed of 19.71 knots, with 5,266 I. H. P.

On March 14, 1891, the *Lalande* obtained a speed of 20.656 knots.

DAVOUT.

It was expected that this cruiser (page 28, No. IX) would be ready for trial early in 1890, but the firerooms were found to be very hot and badly ventilated and many tubes leaked when submitted to water pressure.

New ventilators having been fitted and repairs made, satisfactory trials took place in March, 1891, during which 18 knots were obtained in the open sea without forcing the boilers.

As a result of the discovery of these defects in the *Davout*, the *Suchet*, her sister ship, is to be given 3,429 tons displacement (instead of 3,027) and three new vessels of the same type are to have 3,722 tons.

VESSELS LOST OR STRUCK FROM THE LIST.

Résolue, sailing vessel, condemned in 1890.

Linois, wooden corvette, condemned in 1890.

Biche, paddle-wheel gunboat, condemned in 1890.

Gladiateur, wooden gun vessel, condemned in 1890.

Corse, old-type gun and dispatch vessel, condemned in 1890.

Orohéna, sailing vessel, condemned in 1890.

Travailleur, paddle-wheel, condemned in 1890.

Levrard, small gunboat, condemned in 1890.

Bossant, small gunboat, condemned in 1890.

Rapide, paddle-wheel corvette, condemned in 1891.

Taureau, armored coast-defense vessel, built in 1865, condemned in 1890.

Fanfare, wooden gunboat, condemned in 1890.

Montcalm, armored cruiser, built in 1868, condemned in 1891.

D'Estrées, wooden corvette, condemned in 1891.

Bouvet, composite dispatch vessel, went ashore on coast of Africa; afterwards condemned, 1891.

Indre, transport, condemned in 1891.

Garonne, transport, condemned in 1891.

Creuse, transport, condemned in 1891.

Seudre, transport, condemned in 1891.

Orne, transport, condemned in 1891.

Framée, gunboat, condemned in 1891.

TORPEDO BOATS.

France is showing great activity in this branch of naval construction, having no less than 99 torpedo boats in course of construction, equipment, or transformation, viz: seventeen *torpilleurs de haute mer* of from 104 to 150 tons displacement, distributed as follows: *Alarme*, *Aventurier*, *Défi*, and *Téméraire* at St. Nazaire; *Archer*, *Dragon*, *Grenadier*, *Lancier*, *Grondeur*, and *Véloce* at Havre; *Turco* and *Zouave*, at St. Denis; *Éclair*, *Kabyle*, and *Orage* at La Seyne; *Sarrasin* and *Tourbillon* at Bordeaux.

Twenty-five first-class boats of about 80 tons displacement; thirteen at Havre, three at St. Denis, three at Paris, three at Bordeaux, and three at Le Creuzot.

Twenty-nine second-class boats of about 53 tons displacement; five at Cherbourg, four at Havre, three at Nantes, three at Le Creuzot, three at Bordeaux, and eleven at Brest.

One submarine boat, the *Sirène*.

Twenty-seven of the 35-metre type, being reconstructed.

STEAM TRIALS.

The Minister of Marine, in view of the fact that the boilers of torpedo-boats, which are of the locomotive type, suffer greatly from too frequent pressure tests, has ordered that these boilers are to be tested in future only once a year, if possible after extensive repairs, and then only by hydraulic pressure, the latter not to exceed the working pressure by more than three atmospheres.

Whenever a torpedo boat is docked the boilers are merely to be thoroughly overhauled.

No. 131 had trials in the summer of 1890 which gave very satisfactory results, a speed of 21.214 knots being obtained. No. 133 gave a mean of 20.7 knots during a 3 hour run, and 21 knots maximum speed. No. 135 made the run from Havre to Cherbourg, 72 miles, in 3 hours and 40 minutes, without forcing her engines.

The following table gives the official results of trials of the first-class boats, Nos. 126, 127, and 128:

	Speed.	Revolutions per minute.	Boiler pressure.	Effective H. P.	Coal consumption per hour.
	Knots.		*Pounds.*		*Pounds.*
No. 128, progressive trial ...	19, 38	289	....	941	....
No. 126, official two-hour trial	21, 087	308	135	About 1,000.	1, 892
No. 127, official two-hour trial	20, 695	287. 5	138		1, 760
No. 128, official two-hour trial........................	20, 975	308. 5	138		2, 068
Mean	....	....	....	....	1, 907

The mean horse-power being about 1,000, the coal consumption per horse-power is about 1.9 pounds. M. Normand, the builder of these boats, states that in his former engines the coal consumption has been about 2.3 pounds, and in those of similar compound engines it has reached 3 pounds and more.

No. 128 was afterwards given a trial to ascertain the coal consumption at 10 knots speed.

During two runs of 8 hours each the consumption per horse-power, per hour was 1 pound and .98 pound respectively.

SUBMARINE TORPEDO BOATS.

GYMNOTE.

(Page 32, No. IX, and page 453, No. VIII.)

During the Spring and Summer of 1890 this boat was in the hands of the *défense mobile* of Toulon, regularly commissioned under the same conditions as the other vessels attached to this service, and she took part in all the military exercises very successfully.

A series of experiments were made in August, 1890, to ascertain whether the boat could escape from and reënter a harbor blockaded by torpedo boats which were on the lookout for her.

Several of these last were posted on a line between Cape Cépet and St. Marguerite with orders to watch for the *Gymnote* and pursue her if discovered.

At the appointed hour the *Gymnote* went down for 40 minutes, during which time she crossed the line without being observed and came to the surface two miles and a half beyond it. In returning she passed immediately under one of the boats and was seen for an instant but not distinctly enough to be pursued.

These trials have been considered sufficiently successful by the French Ministry to warrant the building of another submarine vessel of a similar type, but larger, to be named the

SIRÈNE.

Length, 131 feet; displacement, 250 tons; speed, 14 knots.

She has been designed by M. Ramazzotti, and orders were given for her immediate construction in October, 1890. She is to cost $154,872, and her name will probably be changed to *Gustave Zédé.*

GOUBET.

(Page 33, No. IX, and page 454, No. VIII.)

A report from Cherbourg February, 1891, states that the *Goubet* is experimented with, nearly every day, and that different parties of naval officers are sent on board to become familiarized with the mysteries of submarine navigation and the peculiar working and management of this boat, which it is now asserted is completely under the control of its crew. It is also reported that Vice-Admiral Lespés, who is superintending the experiments on behalf of the Admiralty, has expressed his great satisfaction at the performances of the *Goubet*, and as a further test has ordered several surgeons of the fleet to go down in her, in turn, and furnish separate reports on the arrangement of the contrivances to insure free respiration and comfort to the inmates during periods of prolonged submersion.

In May, 1891, the boat was given official trials before a Commission presided over by Admiral Gervais, Commandant of the Northern Squadron. She ran about the harbor for some time at a rate of about 6 knots, going down and rising at will. Then, by request of the Commission, she went down to a depth of 5 metres and preserved at this depth an absolute immovability.

These trials are said to have been a veritable success for the *Goubet*, and all the spectators of her performances were greatly impressed with her power as an engine of war.

ITALY.

The Superior Council of the Marine, at a meeting held in December, 1890, formulated a recommendation that in the future all naval material for use of the Italian fleet be bought in Italy.

The question of employing petroleum as fuel on board ship was also discussed and fully approved.

Submarine mines are to be carried by Italian men-of-war; eighteen by each battle ship, and six by each cruiser.

The Budget for 1891-'92 provided $23,518,093 for the Navy, of which $5,580,000 were to be devoted to the construction and equipment of new ships, but a supplementary estimate presented by the Minister of Marine, on March 2, 1891, introduced certain economies which resulted in a saving of $1,308,567 on the total amount required.

In regard to these economies it is understood that the present Government has no intention of weakening the naval strength of Italy, but will confine them principally to the administrative departments; one less ship will be kept in commission and the personnel will be reduced by about 2,400 men.

VESSELS PROPOSED OR LAID DOWN.

The building programme, as outlined on pages 36 and 37, No. IX, is being carried out, and work in the Italian dockyards is going on actively.

A reduction in the amount required for arming and equipping war ships in 1891-'92 was rendered possible by delaying the completion of the cruisers *Etruria*, *Liguria*, and *Umbria*, and transferring a portion of the expense to next year's Budget.

IRIDE (A)—EURIDICE (B).

Torpedo vessels, of the *Partenope* type (page 343, No. VIII), lately constructed by the Government at Castellamare, have been given the above names. The contract for another vessel of this type was given to Orlando Brothers, of Leghorn, in April of this year.

ATLANTE—ERCOLE.

Supply vessels mentioned as *G* and *H* on page 37, No. IX, are being built by Messrs. Cravero & Co., of Genoa.

ELBA.

Formerly known as cruiser D, is to be of the *Lombardia* class.

VESSELS LAUNCHED.

SARDEGNA.

This battle ship, which will rank as one of the most formidable war vessels in the world when she is completed, was launched at Spezia on September 20, 1890. She is to be of the *Re Umberto* type (page 343, No. VIII), but is larger and has more powerful machinery. Her main battery, like that of the *Umberto* and *Sicilia*, consists of four 13.5-inch guns on two polygonal, inclined, barbettes; eight 6-inch breech-loaders and sixteen 4.72-inch R. F. G. The auxiliary battery consists of twenty-nine rapid-fire and machine guns; and five torpedo-tubes (two of which are submerged) complete the armament.

Protection.—Steel side armor 3.9-inches thick extends from 3 feet below the water-line to the rail for 249 feet of the ship's length; transverse bulk heads 2.7-inches; barbettes 14.2 inches thick inclined at an angle of 23 degrees; protective deck, 2 to 4.3 inches; conning tower and ammunition tubes 11.8 inches; tube from conning tower 5.9 inches.

Motive power.—Four sets of vertical triple-expansion engines with cylinders 39, 59 and 88 inches in diameter by 51-inch stroke.

Eighteen cylindrical boilers are divided into six groups of three boilers each. Each group occupies a separate water-tight compartment having its own apparatus for coal supply, ventilation, etc., and is entirely independent of all the others.

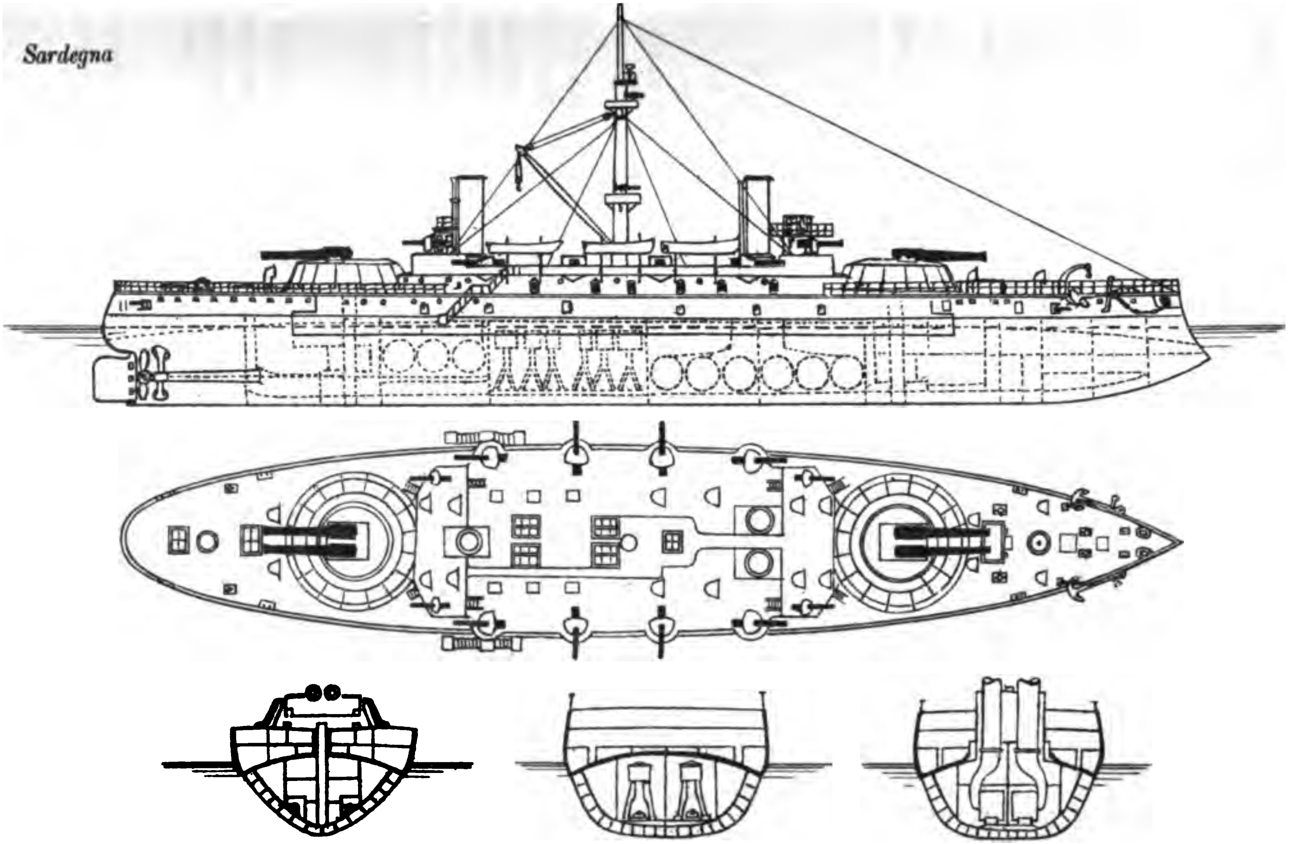
The horse-power which Messrs. Hawthorne, Guppy & Co., of Naples, have contracted to supply is 15,200 with natural draft and 22,800 with forced draft.

This maximum power is expected to give the ship a speed of 20 knots, which is notably superior to that of any other battle-ship in existence.

Dimensions.—Length, 429 feet; beam, 77 feet 8 inches; draught, 29 feet; displacement, 13,940 tons.

ARETUSA—URANIA.

Torpedo vessels (page 343, No. VIII), were launched at Leghorn and Genoa in March and June, 1891.



Sardegna

UMBRIA—ETRURIA.

Protected cruisers of 2,281 tons (page 343, No. VIII), were launched on April 23, 1891, from the shipyard of Orlando Brothers, Leghorn.

STEAM TRIALS.

ANDREA DORIA.

This battle ship (page 38, No. IX) successfully concluded a series of progressive trials during the Summer of 1890. On July 15 a full-power trial took place off Spezia, during which everything worked well, and an air pressure of three-fourths of an inch was found quite sufficient to maintain the power required. The result of the day's run was a mean horse-power of 10,500, and an average speed of 16.1 knots.

RE UMBERTO.

The engines of this battle ship had a very successful preliminary trial in the Royal Arsenal at Naples during August, 1890. They are to indicate 20,000 horse-power and are duplicates of those to be supplied to the *Sicilia*, now building at Venice.

A further test was then given the machinery by running the ship from Naples to Spezia and back again under natural draft. The speed obtained was 17.5 knots, and everything worked smoothly.

The official trials will probably take place as soon as the ship has received her battery and other weights.

FLAVIO GIOIA.

A cruiser of 2,524 tons displacement, has been subjected to a full speed trial, with petroleum as auxiliary fuel, and is said to have obtained good results.

Successful trials have also been made with petroleum fuel on board the *Castelfidardo* and *Ancona*, and so satisfactory do the results seem to have been that a course of instruction in the necessary procedure for the application of liquid fuel is about to be commenced (February, 1891) on board the *Ancona*.

MOROSINI,

A battle ship of 10,830 tons displacement, is similar to the *Andrea Doria* described on page 203, No. V. During trials which took place in December, 1890, a speed of 16 knots was obtained with only two-thirds power.

CONFIENZA,

Torpedo vessel (page 204, No. V), had her final trials in June, 1890, and is said to have obtained very satisfactory results.

VESSELS LOST OR STRUCK FROM THE LIST.

Torpedo boat No. 105 S; lost off the coast of Italy in October, 1890.

Varese, armored cruiser, built in 1866, struck from Navy List, June, 1891.

TORPEDO BOATS.

It is reported (December, 1890) that the Italian Government has ordered six first-class boats of M. Schichau, which are to be similar to the Russian *Adler*, described on page 40, No. IX.

STEAM TRIALS.

No. 104 has been given a series of trials with petroleum fuel which have given good results.

The speed obtained was 22 knots and the boat's steaming radius was increased one-third.

RUSSIA.

The Naval Budget for 1891 amounts to $33,257,542, of which $13,319,435 will be devoted to new construction.

VESSELS PROPOSED OR LAID DOWN.

A battle ship similar to the *Ghangoot*, but probably larger, has been laid down at the Admiralty works, St. Petersburg, and one of 12,400 tons displacement has been commenced at Nicolaieff for the Black Sea fleet.

It is also reported that a new battle ship is to follow the *George the Conqueror* at Sebastopol, and a new armored cruiser, the *Rurik*, at St. Petersburg, as soon as these two vessels are launched.

Two mine-vessels have been ordered of the Motala Company, Gothenberg, Sweden.

A torpedo vessel similar to the *Kazarski* has been recently laid down at Nicolaieff, and two others of the same type are to be built at Elbing, Germany, by M. Schichau.

GREMIASTCHI—OTVAGENII.

Two armored gun boats similar to the *Grossiastchi* (see vessels launched) have been laid down at the Admiralty and Baltic dockyards, St. Petersburg.

A stern-wheel river steamer has been recently constructed by Messrs. Yarrow, of Poplar, for the Russian Government.

This craft, which is an enlarged *Mosquito* (page 16, No. IX), is built of steel in ten sections, each of which measures 10 by 22 feet by 4 feet 6 inches, being thus adapted for transportation by rail.

Her dimensions are: Length, 100 feet; beam 22 feet; load draught, 1½ to 3 feet.

A trial took place in May of this year which is said to have given a speed of 11 knots.

VESSELS LAUNCHED.

TWELVE APOSTLES,

Battle ship of 8,200 tons (page 353, No. VIII) was launched at Nicolaieff in September, 1890.

GHANGOOT,

Battleship of 6,628 tons (page 317, No. VII, and page 353, No. VIII), was launched at St. Petersburg October 20, 1890.

GROSSIASTCHI,

Armored gunboat, of 1,492 tons displacement, was launched at St. Petersburg June 1, 1890.

Armament.—One 9-inch B. L. forward and a 6-inch B. L. aft; eight R. F. G. in broadside and two torpedo-tubes.

Protection.—A 5-inch water-line belt extends to within 40 feet of the bow and terminates in a 5-inch transverse bulkhead; protective deck 1 to 1½ inches thick; a coffer-dam above the belt is filled with water-excluding material.

Motive power.—Two compound engines, estimated to give 2,000 I. H. P. and 15 knots speed.

Dimensions: Length, 236 feet 9 inches; beam, 41 feet 7 inches; draught, 11 feet.

POLE STAR,

Imperial yacht, launched at St. Petersburg June 1, 1890. (See steam trials.)

STEAM TRIALS.

OREL.

This auxiliary cruiser and transport, after her very successful trials in the river Tyne (page 39, No. IX), was given a 6-hour sea-trial during which she made 19.11 knots, with 96.4 revolutions and 9,098 I. H. P. Forced draft was not used.

The *Orel* is the tenth vessel built for the Russian Volunteer Fleet, and is larger than any of her predecessors. Her dimensions are, length, 452 feet; beam, 48 feet; draught, 19 feet 3 inches; displacement, 5,000 tons.

POLE STAR,

Imperial yacht (page 353, No. VIII), has had successful natural-draft trials, during which an average speed of 18.85 knots was obtained with 5,602 horse-power. Engines worked smoothly and there was an entire absence of vibration.

The *Pole Star* is intended to be used in war time as a cruiser, and is, therefore, built with a double bottom and water-tight compartments. She is also fitted with all modern appliances, electric lighting, etc.

TORPEDO BOATS.

In December, 1890, the Minister of Marine ordered eight new torpedo boats for the Black Sea Fleet—two to be built at Odessa, three at Nicolaieff, and three at Sebastopol.

GERMANY

The following notes on the building programme of 1888 (page 354, No. VIII) will show the present state of the work and the amount of money to be expended during the next financial year on the different classes of vessels.

BATTLE SHIPS A, B, C, D.

These four vessels are all in course of construction and are being pushed to completion simultaneously. Three million six hundred and twenty-four thousand dollars is provided to continue work on them during the coming year. (See Vessels Launched.)

ARMORED COAST-DEFENSE VESSELS P, Q, R, S, T, U, V, W, X.

The following sums are granted: For P (Beowulf), $384,000 (third and last payment); for Q, $240,000 (third payment); for R, $360,000 (second payment); for S, $240,000 (first payment); for U, $240,000 (first payment).

The estimates called for $360,000 to commence work on the T, but as this vessel, is to be given out by contract, and the total amount appropriated was too small to build all the ships, it was decided to leave her out of the present Budget and provide for her later.

It is a question whether the new vessels of this class will be built on the original designs, as the *Siegfried* has not proved to be a success as regards speed. (See Steam trials.)

FIRST-CLASS PROTECTED CRUISERS H, J, K, L, M, N, O, P.

The sum of $240,000 (fourth payment) is appropriated to continue work on H, but the money asked for J and K is refused on the ground that, although the first payment on these vessels was provided for in last year's Budget, no work has yet been done on them. It was at first estimated that the cruiser H would cost $1,320,000, but owing to the recent rise in price of labor and materials it is now stated that $1,608,000 will be required to build and equip her.

UNPROTECTED CRUISERS E—ERZATZ ADLER—ERZATZ EBER.

Four hundred and sixty-eight thousand dollars has been granted to continue work on these three vessels. They are to displace 1,880 tons (300 tons more than their predecessors); their estimated speed is 16 knots, and they will carry eight light guns.

IMPERIAL YACHT AND DISPATCH VESSEL.

Three hundred and sixty thousand dollars as a second payment on this vessel is appropriated. She is to be fitted in all respects as a man-of-war.

A floating derrick and a surveying ship are also provided for. (See Torpedo boats.)

VESSELS LAUNCHED.

BEOWULF. (P.)

This coast defense armor-clad, which is a sister ship to the *Siegfried*, was launched at Bremen on November 8, 1890, and will be ready for trials in the Summer of 1891.

FALKE.*

Unprotected cruiser of 1580 tons, was launched at Kiel, on April 4, 1891. She was formerly noted as cruiser "D," and is similar to the *Schwalbe* (page 316, No. VII) but is slightly larger.

PELIKAN.

Mine vessel, mentioned on page 41, No. IX, was launched in the Spring of 1890. She is to have about 1,500 tons displacement.

KURFÜRST FRIEDRICH WILHELM.

A 10,000-ton battle-ship (D), was launched at Wilhelmshaven June 30, 1891.

STEAM TRIALS.

The following order governing the trials of German war-ships has been recently published:

(1) On board all vessels permanently or temporarily commissioned (except vessels for special service, such as school ships, surveying ships, etc., and torpedo boats) the efficiency of the engines, as well as of the engine and fire room personnel, is to be ascertained by a 24-hour full-power trial.

If the ship remains in commission longer than one year, this trial is to be made annually. With this full-power trial, a 3-hour forced-draft trial is to be connected as explained below.

(2) The first trial is under ordinary circumstances to take place as soon as the commanding officer is convinced that the instruction of the engine and fire room personnel has advanced sufficiently to enable them to get the full power of the machinery and boilers.

(3) The trials are to be made as soon as possible after all the boilers have been cleaned, and with the development of all the power that can be obtained by the regular fire-room force.

Deck hands may be used to help in transporting coal to the furnaces, but only when it becomes very difficult to get at the coal (for instance through the emptying of fire-room bunkers), and the fact that deck hands have been employed must be specially mentioned and the reason given.

Steam, throttle, and expansion valves must not be changed during the trial, unless it should be absolutely necessary, when explanations must be made in the appropriate columns of the report.

The apparatus for forced draft must only be used in so far as it is necessary to give the fires and the fire-room personnel the right quantity of air, without increasing the air-pressure.

(4) The trials must be made with ship's bottom as clean as possible, and with a draught corresponding to that when completely equipped and provisioned. They may be made as parts of regular voyages.

(5) Sail must only be carried if it may seem necessary to steady the vessel, and then only fore-and-aft sail.

(6) A repetition of the trial must be made within the year, or, in case of the vessel being commissioned for less than a year, under the following circumstances:

(*a*) If the trial has been interrupted by accidents.

(*b*) If the engine-room personnel has been changed to the extent of one-half or more.

(*c*) If the time between the last trip and the probable date at which the vessel will go out of commission is more than 6 months. In this case the trial shall be repeated shortly before the ship goes out of commission.

(7) Those ships mentioned in (1) are also to have 3-hour forced-draft trials about once a quarter.

These trials are to be made with the pick of the fire-room personnel after thorough cleaning of the boilers and by making use of all forced-draft apparatus. The air-pressure must depend upon the degree of instruction of the fire-room personnel and the condition of the boilers, which latter must never be tested to a dangerous extent.

Under no circumstances must the air-pressure with locomotive boilers exceed 2 inches, or with cylindrical boilers 1.2 inch.

In order to obtain an idea of the performance of the engines for a continuous period, after they have been subjected to an extreme test for a short period, one of the quarterly forced-draft trials is to be so arranged as to fall in the first half of the full-speed (24-hour) trial.

SIEGFRIED,

Coast-defense armor-clad (page 41, No. IX), has not come up to the expectations of her designers in regard to speed, as she has never succeeded in obtaining more than 16 knots.

JAGD—WACHT.

Dispatch and torpedo vessels (page 316, No. VII).

The *Jagd* terminated her trials in the Summer of 1890, during which she accomplished more than 20 knots with 4,000 I. H. P.

The *Wacht* was obliged to leave the German squadron after 6 months' service and remain for some time disabled at Trieste, owing to enormous leakage at the junction of her boiler tubes and tube plates.

VESSELS LOST OR STRUCK FROM THE LIST.

Niobe, wooden frigate, has been condemned to be broken up, or more probably transferred to barrack service, December, 1890.

Rover, wooden brig, condemned in 1890.

Ariadne, *Victoria*, unprotected wooden cruisers, removed from the navy list in 1891.

TORPEDO BOATS.

Of the older torpedo boats, six, being unserviceable, have been struck from the list, and, of the others, six will only last until the end of 1891.

To replace eight of these boats $787,200 is required, and of this sum the present Budget appropriates $528,000.

The following is a list of the German torpedo boats that have been constructed or laid down by the Schichau works at Elbing during the last year. They are all to be delivered before the end of 1891:

10 first-class boats, Nos. 65 to 74, of 110 tons and 24 knots.
1 first-class boat, No. 75, of 145 tons and 26 knots.
5 first-class boats, Nos. 76 to 80, of 125 tons and 25 knots.
16 first-class boats, Nos. 31 to 96, of 110 to 150 tons and 26 knots.
3 second-class boats, of 88 tons and 22 knots.
2 second-class boats, of 90 tons and 23 knots.
13 vedette torpedo boats of 13.5 tons and 18 knots.

SPAIN.

A plan for the reconstruction and reorganization of the Spanish navy having been drawn up by Admiral Beranger, the Minister of Marine, and approved by the Ministry, was finally authorized by a Royal Decree on October 29, 1890.

Admiral Beranger in submitting his project explained that, after consulting the highest authorities on naval matters abroad and considering the special conditions applicable to a country like Spain, which has widely separated colonies and but limited financial means, he had come to the conclusion that the best policy was, first, to provide an effective system of coast defense and then to build a number of very fast cruisers with great coal endurance and sufficient protection.

ROYAL DECREE.

ARTICLE 1. The first-class cruisers to be built for the completion of the Fleet must fulfil the following conditions:

Armament.—Two 11-inch Hontoria B. L., a number of rapid-fire guns, and six torpedo-tubes.

Protection. Armor of sufficient thickness over the artillery, and a system of cofferdams and cellulose at the water-line; armored conning tower and tube.

Speed not less than 20 knots under natural draft; steaming radius 12,000 to 15,000 miles. Maximum draught, 25½ feet.

ARTICLE 2. The second and third class cruisers must have at least 20 knots speed and be otherwise as efficient as their displacement will allow.

ARTICLE 3. The Fleet will be organized in three divisions, as follows:

First Division, Cadiz.—Armored cruiser *Emperador Carlos V*, of 9,000 tons, armored cruisers *Princesa de Asturias* and *Infanta Maria Teresa*, of 7,000 tons, and the protected cruiser *Reina Regente*, of 5,000 tons.

Auxiliary.—Two cruisers of the third class, two torpedo vessels, and three torpedo boats.

Second Division, Ferrol.—One 9,000-ton armored cruiser, to be built; the 7,000-ton armored cruisers *Cardenal Cisneros* and *Aquendo*, and the 4,800-ton protected cruiser *Alfonso XIII.*

Auxiliary.—Two third-class cruisers, two torpedo vessels, and three torpedo boats.

Third Division, Cartagena.—Battle-ship *Pelayo*, 9,902 tons; armored cruisers *Cataluña* and *Viscaya*, 7,000 tons, and protected cruiser *Lepanto*, 4,800 tons.

Auxiliary.—Two cruisers of the third class, two torpedo vessels, and three torpedo boats.

ARTICLE 4. For the defense of ports a system is being studied which will combine movable weapons (torpedo boats) with the necessary lines of submarine mines and torpedoes.

ARTICLE 5. The armor-clads *Vitoria* and *Numancia*, of 7,300 tons, will undergo such modifications in their machinery as may be necessary to increase their speed and place them in condition to be used as men-of-war, in harmony with the provisions of this Decree.

ARTICLE 6. In order to utilize part of the existing material the following vessels will be fitted out and used as transports: *Reina Cristina*, transport for 1,000 infantry; *Reina Mercedes*, for cavalry and munitions of war, and the *Alfonso XII*, as a floating arsenal, torpedo-depôt, and supply vessel to the fleet.

ARTICLE 7. In order to avoid confusion in the classification of Spanish war ships, in the future those which have any armor at all will be designated as "protected" and those which have none as "unprotected."

VESSELS PROPOSED OR LAID DOWN.

EMPERADOR CARLOS V.

This vessel is the fourth of six first-class armored cruisers building Spain (page 42, No. IX), and it was at first intended that she should be a 7,000-ton belted cruiser of the *Maria Teresa* type, but in accordance with the new Naval Policy it has been decided to increase her displacement to 9,235 tons and protect her battery with armor, as in the case of the English ships *Blake* and *Blenheim.*

Her armament will consist of two 11-inch Hontoria B.L., twenty-four R. F. G., and six torpedo-tubes.

The two 11-inch guns are to be carried in turrets 9.8 inches thick, while light side armor and transverse bulkheads protect the rapid-fire guns.

Engines of 15,000 I. H. P. are expected to give 19 knots with natural draft and 20 knots with forced draft. Steaming radius 12,000 miles.

The contract to build this ship has been given to the firm of Vea-Murguía Bros., of Cadiz, and she is to be completed in 40 months.

It is understood that the last two of these cruisers are also to have about 9,000 tons displacement and be similarly equipped.

The contract to build a new torpedo vessel of the *Sharpshooter* type has been awarded to the firm of Vea-Murguía, at Cadiz. The following are its principal requirements:

Armament.—Two 4.72-inch R. F. G.; four 42^{mm} R. F. G.; two machine guns, and four torpedo-tubes.

Protection.—Conning tower 9.7 inches steel; coal over engines and boilers.

Motive power.—Vertical triple-expansion engines, to give 4,600 I. H. P. and 20 knots speed with forced draft. Steaming radius about 2,600 miles at 10 knots.

Dimensions.—Length 232.9 feet; beam, 27 feet; mean draught, 8 feet; displacement, 747 tons.

Estimated cost $504,200.

VESSELS LAUNCHED.

INFANTA MARIA TERESA.

Armored cruiser of 7,000 tons (page 318, No. VII, page 355, No. VIII, and page 42, No. IX) was launched at Bilboa on August 30, 1890.

VESSELS LOST OR STRUCK FROM THE LIST.

Filipinas, a small gunboat built at Hongkong, has been purchased (1890) by the Siamese Government.

Cauto, gunboat, wrecked off Puerto-Plata in April, 1891.

TORPEDO BOATS.

PERAL.

This submarine boat (page 454, No. VIII, and page 43 No. IX) was subjected last summer to a very thorough series of trials, and the conclusions of a Technical Trial Board, as well as those of the Superior Council of the Navy, have been published in full.

It was decided after much deliberation that the invention of Lieutenant Peral involved no new principles, that it did not fulfill the conditions promised by its designer, and that the problem of submarine navigation, as far as it touched the question of coast defense, had not yet got beyond the domain of experiment.

Both of these bodies, however, concluded that it was well to follow up this line of investigation, and they therefore recommended that Lieutenant Peral be authorized to design and build a new and larger boat with which to continue his experiments.

Plans for a 120-ton boat were accordingly prepared by this officer, but as he failed to agree to certain conditions imposed by the Council, and claimed more liberty of action than they were willing to grant, the work of construction was not undertaken.

AUSTRIA.

The Budget for 1891 appropriates the following sums for the construction of ships, machinery, and boilers:

ORDINARY ESTIMATES.

1. Protected cruiser *Kaiserin Elisabeth*, of 4,200 tons, to take the place of the *Kaiser*. Fourth payment	$260,000
2. Torpedo-depot ship *Pelikan* in place of the *Elisabeth*. Third payment	120,000
3. A tank vessel with apparatus for distilling. Second payment	40,000
4. For new engines and repairs to the battle-ship *Tegetthoff*. First payment	120,000
5. New boilers	35,200
Total ordinary expenditure in 1891	575,200

EXTRAORDINARY ESTIMATES.

1. Armored cruiser C, of 5,200 tons. Second payment	$216,000
2. For commencing torpedo boats	36,000
3. A mine vessel of 200 tons. Second payment	20,000
4. Danube monitor No. I (*Theiss*). Second payment	72,000
5. Danube monitor No. II. First payment	32,000
6. Torpedo vessel of about 500 tons. First payment	50,400
Total extraordinary expenditure in 1891	426 400
Total expenditure on the construction of ships, machinery, and boilers in 1891	1,001,600

THEISS.

The first of two small protected gunboats of the *Monitor* type, which have been ordered at Buda Pesth for the Danube flotilla, is now in course of construction.

These vessels resemble a monitor only in their external appearance, as their armor is nowhere more than 2.9 inches thick, and their batteries consist only of five light rapid-fire guns. Displacement, 488 tons; T. H. P., 1,200.

VESSELS LAUNCHED.

KAISERIN ELIZABETH.

First-class protected cruiser of 4,060 tons was launched at Pola on September 25, 1890.

In all but a few unimportant details she is a sister ship of the *Franz Josef*, described on page 357, No. VIII.

PELIKAN.

Torpedo-depot ship of 2,431 tons displacement and 3,200 horse-power was launched at the Schichau Works, Elbing, on March 22, 1891.

She will carry 36 torpedoes and be armed with two 5.9-inch B. L. and eight R. F. G.

NAIAD.

A steel tank vessel, provided with a powerful distilling apparatus, has also been recently completed by M. Schichau for the Austrian Government.

STEAM TRIALS.

TRABANT.

Torpedo vessel has had successful trials and been accepted by the Government.

CHINA.

VESSELS PROPOSED OR LAID DOWN.

KONG BIN—KONG HI.

Two small cruisers or torpedo vessels of about 1,000 tons displacement have been laid down at the Foochow Arsenal. In February of this year the *Kong Bin* was nearly ready for launching, and the *Kong Hi* nearly completed.

STEAM TRIALS.

PING YUEN.

Armored coast-defense vessel, of about 2,600 tons displacement, was completed at Foochow last year, and has had trials which are not considered satisfactory. She is said to have attained a maximum speed of 10.5 knots on her trial trip and to make 9 knots in ordinary cruising.

Armament.—One 10.2-inch Krupp B. L. on a barbette forward; two 5.9-inch Krupp B. L. on sponsons amidships; eight R. F. G., and four torpedo tubes.

Protection.—A complete water-line belt of 8-inch armor; protective deck, 2 inches; barbette and conning tower, 5 inches.

Motive power.—Triple expansion engines of about 2,400 I H. P.

Dimensions.—Length, 200 feet; beam, 40 feet; draft, 16 feet.

CHILI.

The following notes concerning Chilian war ships will show what additions have been recently made to the fleet, as well as some changes in the older vessels, which are interesting in connection with their performances during the present war.

All of the original navy went with the revolutionary party except some (8?) of the torpedo boats; but since the commencement of the war, President Balmaceda has come into possession of the new torpedo-vessels *Lynch* and *Condell*, the corvette *Pilcomayo*, and the merchant steamers *Imperiale*, *North America*, and *Chiloe*. (See note under vessels launched.)

The only new ships obtained so far by the insurgents are merchant steamers, four of which are known to be the *Itata*, *Aconcagua*, *Maipo*, and *Bio Bio*.

NOTES ON INDIVIDUAL SHIPS.

Almirante Cochrane.—Battle ship, of 3,560 tons, has a new armament. The battery now consists of five 8-inch 14-ton Armstrong B. L. R. in the gundeck casemate, and a number of Hotchkiss 57-millimetre R. F. and 37 millimetre R. C.

A sixth 8-inch gun, which formed part of her battery when the ship left England, has proved defective and been put on shore.

There is one torpedo-tube on each bow and one in the stern, all above water, and a spare tube is carried on the main deck amidships.

Imperiale.—A steamer, of about 2,700 tons displacement and 3,000 horse-power, was built at Birkenhead, in 1889, for the Compañia Sud Americana de Vapores, and remained in the service of that company until she was seized by President Balmaceda last January. She is now employed as an armed transport, and carries a battery of twelve guns, three of which are rapid-firing. Her speed is said to be 16 knots.

Itata.—Armed transport, employed by the revolutionary party, is an iron steamer, of 1,766 tons displacement. She was built at Liverpool, in 1873, for the Compañia Sud Americana de Vapores, of Valparaiso.

Aconcagua.—Now an armed transport; formerly belonged to the Pacific Steam Navigation Company. Her displacement is 4,106 tons, and she is said to be able to make 14½ knots average speed. Is said to have been considerably damaged during a running fight with the Government vessels *Lynch* and *Condell*, off Caldera, last April.

Chiloe.—Another of this company's vessels is mentioned as forming part of the Government fleet at Valparaiso, in May, 1891. She is an iron screw steamer, of 2,309 tons displacement.

Maipo.—An armed transport, of 2,295 tons, was at first seized by the Government party, but has since fallen into the hands of the oppositionists, who cut her out of the harbor of Valparaiso under the guns of the forts. She was built at Glasgow, in 1882, for the Compañia Sud Americana de Vapores.

North America.—A steamer said to have been purchased in the Argentine Republic by President Balmaceda. . (Authority unreliable.)

Bio Bio.—Now employed as a transport. Formerly belonged to the Compañia Sud Americana de Vapores. Was built at Glasgow in 1888. Has 713 tons displacement.

O'Higgins.—An old-type screw corvette, built in 1867; was seriously damaged in an engagement with the forts at Valparaiso. One shot passed completely through her and another struck a gun on the quarter-deck, tearing up the deck, disabling the piece, and killing nine men.

Magellanes.—A composite gun vessel of 950 tons displacement, built in 1874. Had an engagement at Chañaral, on April 24, with the *Lynch*, *Condell*, and *Aldea*, in which she received some injury, but was finally successful in driving off her assailants. The port forward battery was badly damaged, portions of her gun-carriages demolished, and some of her rigging carried away.

Sarjento Aldea.—Torpedo boat, of 70 tons displacement and 700 I. H. P.; was nearly blown to pieces in her action with the *Magellanes*, on April 24. Her smoke pipe and masts were shot away and her upper works badly damaged.

VESSELS LAUNCHED.

CAPITAN PRAT.

Battle ship, of 6,900 tons displacement (page 358, No. VIII,) was launched at La Seyne, on December 20, 1890.

In the following description of her armament it will be noted that the secondary battery now consists entirely of rapid-fire guns instead of breech-loaders, as at first intended:

Four 9.45-inch Canet B. L. are mounted in barbette turrets, one forward, one aft, and one on each side amidships. These turrets are all equipped with Canet central loading tubes, so that the gun can be loaded in any position, and what makes the installation of peculiar interest is that while the turrets can be worked by hand in case of necessity, electricity has been employed instead of hydraulic power as a motor. Eight 4.72-inch Canet R. F. G. are mounted on carriages of a special type, which can be operated either by hand or by electricity; they are placed in pairs in closed turrets, two on each side of the ship. The auxiliary armament consists of four 57^{mm} and four 47^{mm} R. F. G., six 37^{mm} R. C., seven Maxim machine-guns, and four Canet torpedo-tubes.

This is a powerful and well protected battery, but the most interesting feature connected with it, is the substitution of electricity for hydraulic power in working the guns and turrets.

PRESIDENTE ERRAZURIS—PRESIDENTE PINTO.

Protected cruisers, of 2,080 tons displacement (page 359, No. VIII and page 46, No. IX), were launched in June and September, 1890, at La Seyne, France.

Their batteries consist entirely of rapid-fire guns, which, like those of the *Capitan Prat*, are worked by electricity. (See steam trials.)

At last accounts these three new vessels, which have been held by the French authorities pending a decision by the courts respecting their delivery to the Chilian Government, had been released, and were soon to sail to join President Balmaceda's forces.

STEAM TRIALS.

PRESIDENTE ERRAZURIS—PRESIDENTE PINTO.

The *Errazuris* had very successful trials under induced draft (combustion activée) in December, 1890. The mean of six runs over the measured course (6.73 nautical miles) was 18.4 knots. A subsequent natural draft trial gave 17.3 knots.

The machinery worked well and showed no signs of weakness.

The *Pinto* completed her sea trials in May, but no details have yet been received concerning them.

ALMIRANTE LYNCH—ALMIRANTE CONDELL.

The trials of these two torpedo-vessels (page 46, No. IX) have given great satisfaction both as to speed and sea-going qualities.

The *Lynch* made a mean speed of 21.22 knots on September 25, 1890. In October the *Condell* made a 3-hour run at sea, which gave the following approximate results:

Speed, 20.313 knots; I. H. P., 4350; revolutions, 270; boiler pressure, 143 pounds; vacuum, 27 inches; air pressure, 2¼ to 2½ inches.

The weather was very unfavorable for the speed trials of such a small vessel, as the wind was blowing with a force of 7 and the sea was rough, but she behaved well, and though when steaming to windward she was enveloped in clouds of spray, no solid water came on board.

The vibration aft was considerable, but less than is usual in vessels of this class.

An examination of the machinery failed to detect any sign of straining or weakness.

The trials for coal endurance took place on October 7 when a 6-hour continuous run at 11 knots gave a consumption of 88 pounds per knot (the contract required that it should not exceed 100 pounds). At this rate the vessel has a steaming radius of 2,500 miles with the normal coal supply of 100 tons.

Both of these ships have been somewhat damaged in recent engagements, but at last accounts were still serviceable.

A complete description of them is given in the article on torpedo vessels, Chapter IX of this number.

VESSELS LOST OR STRUCK FROM THE LIST.

Blanco Encalada.—A casemated battle ship of 3,560 tons displacement was sunk in the harbor of Caldera in April of this year by a torpedo, fired by the torpedo vessel *Almirante Lynch.*

The secondary battery of the Blanco is said to have consisted, at the time of the fight, of four 6-pounder R. F. G., two on the forecastle and two on the poop, four 1-inch Nordenfeldts mounted on the forward and after bridges, one H. R. C. in the top, and two machine guns.

The complement of the ship at the time of the attack consisted of but 80 well-trained men, the remainder of her crew being composed of men taken from the shore with little experience of life on board ship or knowledge of their duties.

The vessel lies in about 10 fathoms of water on a hard sand bottom. It is reported that an attempt will be made to raise her. The hole in her side is said to be 18 feet long and from 4 to 7 feet wide.

Mary Florence.—A tug employed by the Government and armed with a 100-pounder gun was destroyed in Valparaiso Harbor by the *Blanco Encalada*, April, 1891.

Guacolda.—Torpedo boat destroyed by the *Magellanes* in April, 1891.

DENMARK.

VESSELS LAUNCHED.

HEKLA.

Protected cruiser of 1,300 tons (page 323, No. VII) was launched at Copenhagen, November 28, 1890.

GREECE.

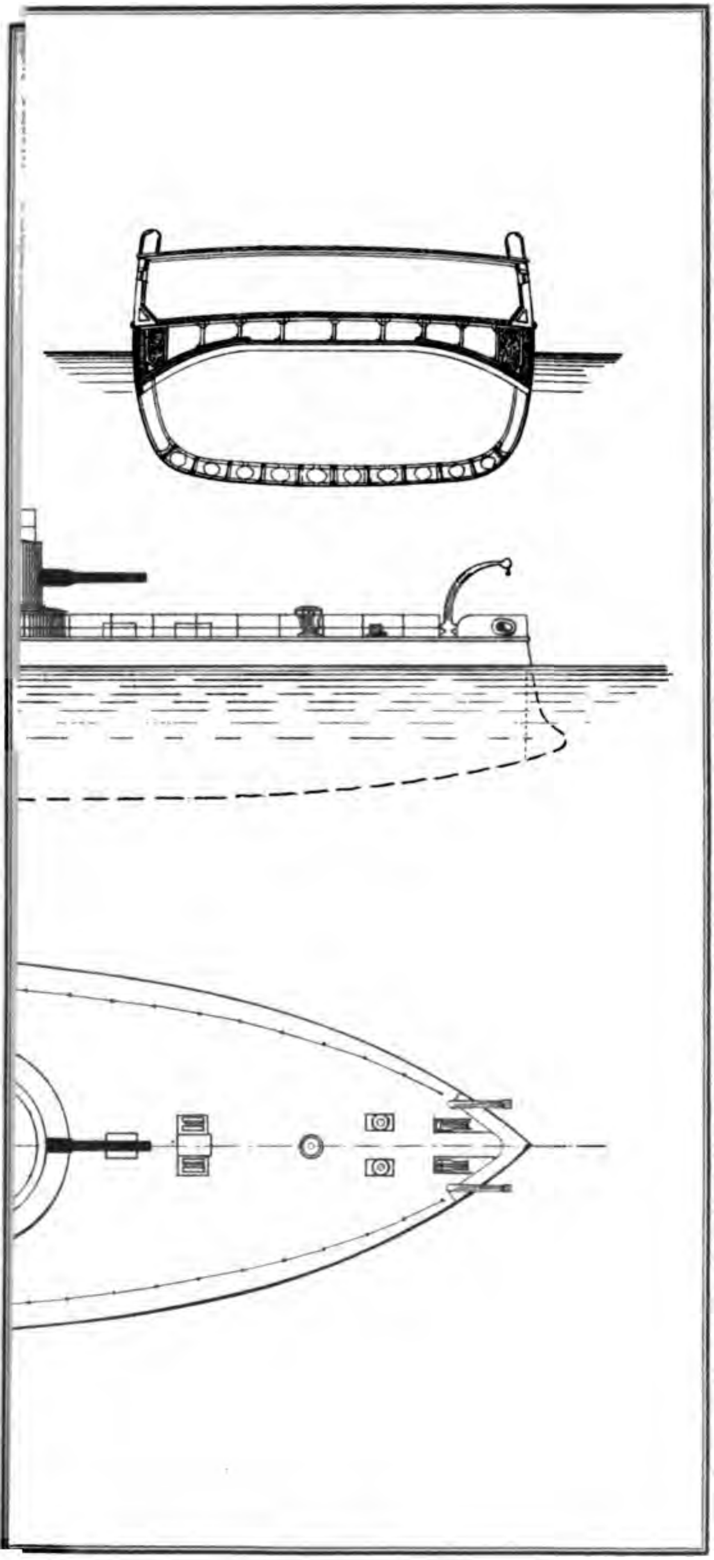
STEAM TRIALS.

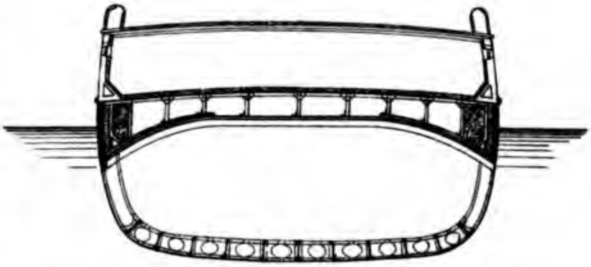
HYDRA—SPETSIA—PSARA.

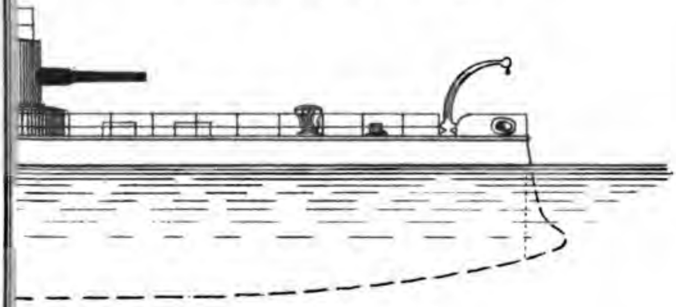
Armored coast-defense vessels (page 360, No. VIII, and page 48, No. IX) have all been completed in France during the last year, and subjected to trials, which gave very satisfactory results.

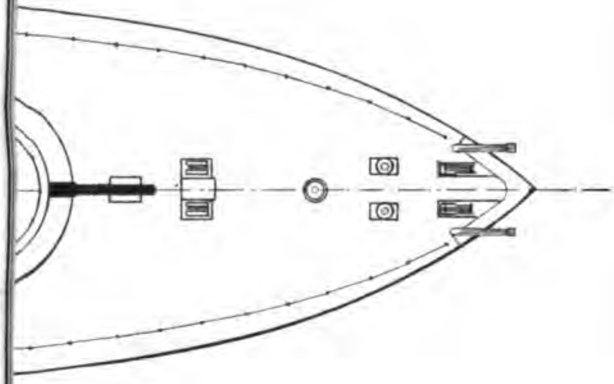
The *Hydra* obtained a mean speed of 17.04 knots, and the *Spetsia* 17.55 knots, with 6,930 I. H. P., during 3 hours continuous steaming.

The *Psara* has also been reported as successful, but no details have been published.









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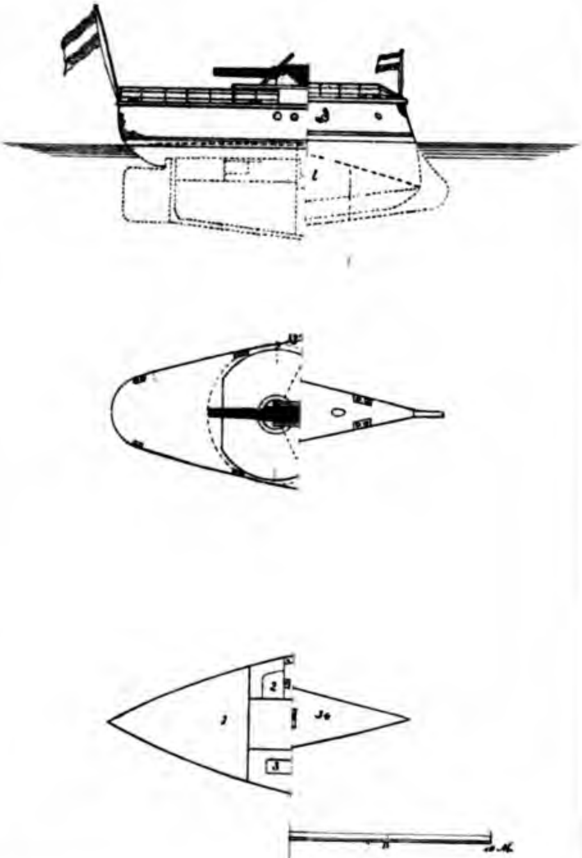


SUMATRA,

A partially protected cruiser, recently completed at the Kon Fabrick Works, Amsterdam.

Armament.—One 8.3-inch B. L. on central pivot forward; one 5.9-inch B. L. on central pivot aft.; two 4.7-inch B. L. on sponsons abaft the bridge; two torpedo-tubes.

Protection.—An armored deck, having a mean thickness of 1.5 inches, covers engines, boilers, magazines, and steering gear and extends from 14 inches above water-line at the center to 4 feet below it at the sides; conning tower, 5.9 inches with a 3-inch tube; gunshields, 1.57 inches; cellulose belt at water-line and coffer-dams filled with the same material about hatches.

Motive-power.—Two vertical triple-expansion engines, to give 3,500 I. H. P. and 17 knots speed during four consecutive hours.

Dimensions.—Length, 229 feet 7 inches; beam, 36 feet 9 inches; depth, 22 feet; draught, 14 feet; displacement with 170 tons of coal, 1,703 tons.

SUMBAWA—LOMBOK.

Small unarmored cruisers for service in the Dutch East Indies, are reported as building at Veissingen and Amsterdam.

Armament.—Three 4.7-inch, one 2.9-inch, and two 1.5 inch R. F. G.

Motive-power.—Triple-expansion engines of 850 I. H. P.

Dimensions.—Length, 158 feet; beam, 26 feet 3 inches; depth, 13 feet 8 inches; draught 10 feet 5 inches; displacement, 600 tons.

A third cruiser of similar type is said to be in the hands of the Maas Company of Rotterdam. She carries a battery of 6 light guns, has 400 tons displacement and about 10.5 knots speed.

STEAM TRIALS.

SUMATRA.

Results of recent trials.

Trial.	Revolutions per minute.	I. H. P.	Speed.	Coal consumption per hour and per I. H. P.	Steaming radius with 170 tons of coal.	Steaming radius with 220 tons of coal.	Remarks.
			Knots.	*Pounds.*	*Miles.*		
1	106	625	10.3	1.98	757	1,000	4 hours' trial; natural draft.
2	161.5	2,010	15.	1.73	400	520	6 hours' trial; natural draft.
3	180	2,750	16.3	....	....	....	1¼ hours' trial; forced draft.
4	189	3,318	17.1	....	....	....	Runs on measured mile; forced draft; steam pressure, 145 pounds.
5	100	....	7.5	....	....	....	Using only one engine.
6	120	....	8.75	....	....	....	
7	140	....	10.	....	....	....	

TORPEDO BOATS.

LAMONGAN—MAKJAN—NOBO.

First-class boats now in course of construction in Holland. The *Nobo* was launched at Amsterdam on April 22, 1891.

JAPAN.

The Minister of Marine informed Parliament in March 1891, that the total amount of warship tonnage required for the defense of the Empire was 120,000, but that the present tonnage of the Japanese navy was only about 50,000.

It was accordingly decided by the congress that 5,000,000 yen (about $4,000,000) should be appropriated to the building of new ships, and that this amount should be expended in providing two cruisers of the second class, one cruiser of the third class, and one torpedo-vessel.

The Government is said to have decided on the following programme of new construction:

The total number of ships to be built in addition to those mentioned above is 22, viz: 2 armor-clads of 9,500 tons, to cost $5,609,316 apiece; 3 armored cruisers of 6,000 tons, to cost $3,371,152 apiece; 1 first-class cruiser of 4,500 tons, to cost $2,641,319; 2 second-class cruisers of 3,500 tons, to cost $1,922,809 apiece; 1 third-class cruiser of 2,500 tons, to cost $1,336,996; 3 third-class cruisers of 1,500 tons, to cost $856,765 apiece; 7 torpedo vessels of 750 tons, to cost $619,159 apiece; 3 torpedo vessels of 500 tons, to cost $459,032 apiece; total, 62,250 tons, and $37,437,524.

(The above is taken from a Japanese newspaper, but requires confirmation, especially in regard to the cost of new ships.)

The note on page 49, No. IX, concerning new cruisers is incorrect. Later information is to the effect that the *Oshima* is building at the Onohama dock-yard and the *Akitsushima* at *Yokosuka*. There is no vessel named *Akutsima.*

VESSELS PROPOSED OR LAID DOWN.

The contracts for two armored coast-defense vessels (page 49, No. IX) are said to have been given to the Société des Forges et Chantiers de la Méditerranée at La Seyne, but their designs will not be decided upon until the new vessels of this type have been thoroughly tested and compared.

VESSELS LAUNCHED.

CHIODA.

This armored cruiser, which is mentioned as the *Shiodo* on page 361, No. VIII, was launched by Messrs. G. & J. Thomson at Clydebank on June 3, 1890.

THE JAPANESE CRUISER "CHIYODA."

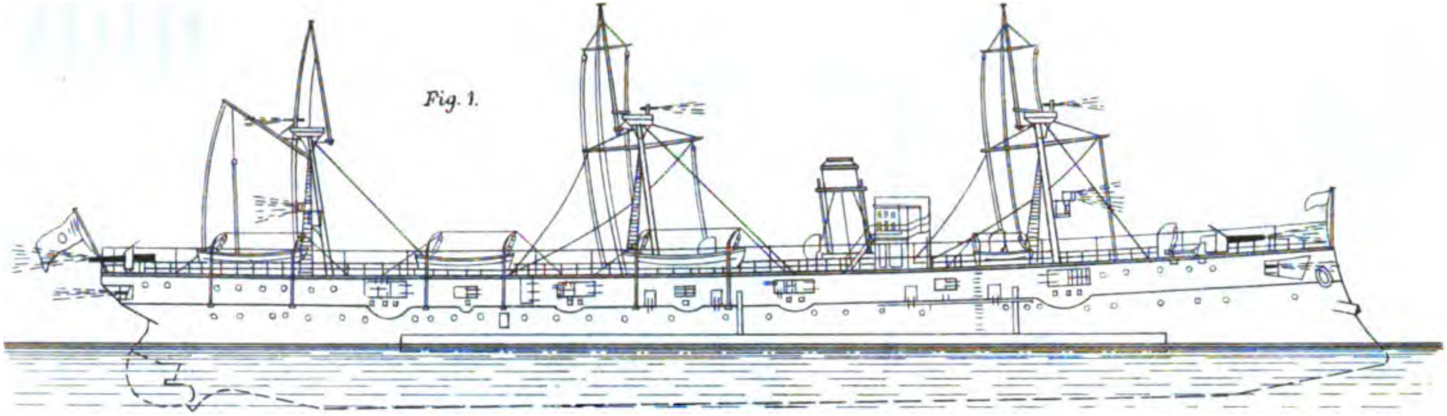


Fig. 1.

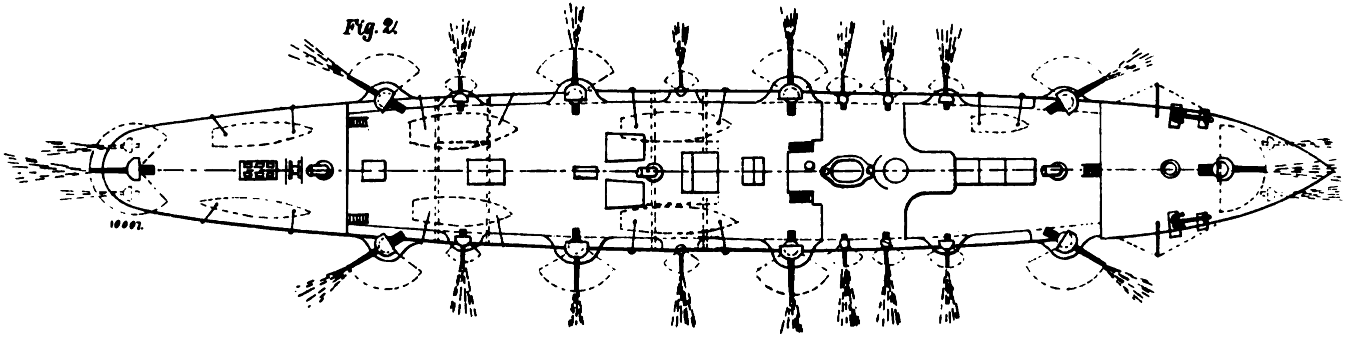


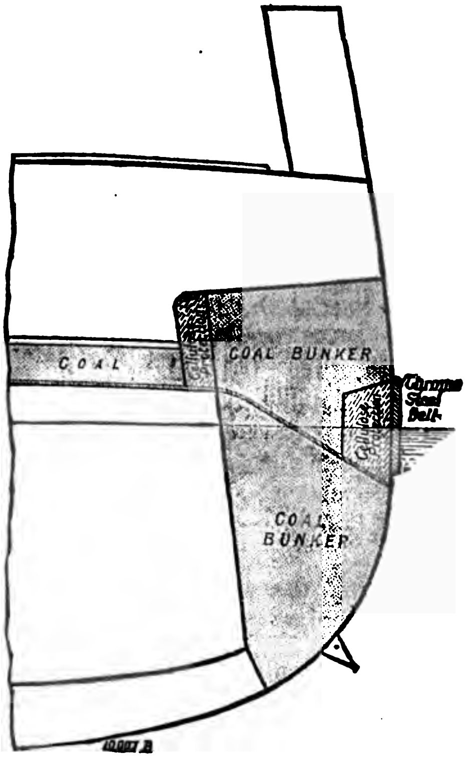
Fig. 2.

The *Chyoda* has been built from designs which were in the first instance supplied to the builders by the Japanese Government, but several important alterations have been made in the original plans, partly at the suggestion of the builders in concert with the Japanese naval constructors.

The following details concerning her have been published:

Armament.—Ten 4.7-inch Armstrong R. F. G.; fourteen 47^{mm} H. R. F., three Gatling machine guns, and three torpedo-tubes.

Protection.—The water line for about two-thirds of its length amid ships is covered by a belt of rolled steel plates bolted on to the outside of the shell plating, the total thickness of the steel side along the belt being 4⅝ inches. A protective deck having a mean thickness of 1 inch extends from stem to stern, and a short distance above it is an ordinary deck, the intervening space being arranged for coal and coke. The interior of ship is divided into 84 water-tight compartments, and there



is a double bottom on the cellular system. Further protection is afforded the machinery and boilers by the arrangement of the coal bunkers and by a cellulose belt.

Motive power.—Two sets of triple-expansion engines, designed to run at 230 revolutions and develop 5,600 H. P. and 19.5 knots speed.

Dimensions.—Length, 310 feet; beam, 42 feet; depth, 23 feet 8 inches; mean draught, 14 feet; displacement, 2,450 tons.

According to the original design the ship was to have been fully rigged as a bark, with a view of economizing coal when cruising. The designers, however, decided that this consideration was not worth the weight and expense involved, and adopted a purely fighting rig, with armored tops and light-yards for signaling purposes.

CHISIMA.

A torpedo vessel of 753 tons displacement was launched at St. Nazaire on November 27, 1890. Her engines are expected to develop 5,000 I. H. P. and give a speed of 22 knots. (See Steam trials.)

HASHIDATE.

Coast defense vessel of 4,277 tons (page 278, No. VI) was launched at the Yokosuka dockyard on March 24, 1891. This vessel, like her sister ships, *Itsukushima* and *Matsushima*, belongs to a type which combines good speed and sea-going qualities with an effective armament, but no hull armor is carried and the only protection against injury at the water-line is a very complete system of water-tight compartments and cofferdams filled with cellulose.

A barbette turret containing one 12.6-inch B. L. and protected by 11.8-inch armor is situated well forward on the *Itsukushima* and *Hashidate*, but is placed aft on the *Matsushima* with the intention of improving her sea-going qualities.

Two 4.7-inch R. F. G. are placed in the bow instead of one heavy gun as in the two sister ships. Five 4.7-inch R. F. G. are carried in each broadside.

A protective deck 1.6 inches thick extends fore and aft, and all hatches are surrounded by armored glacis.

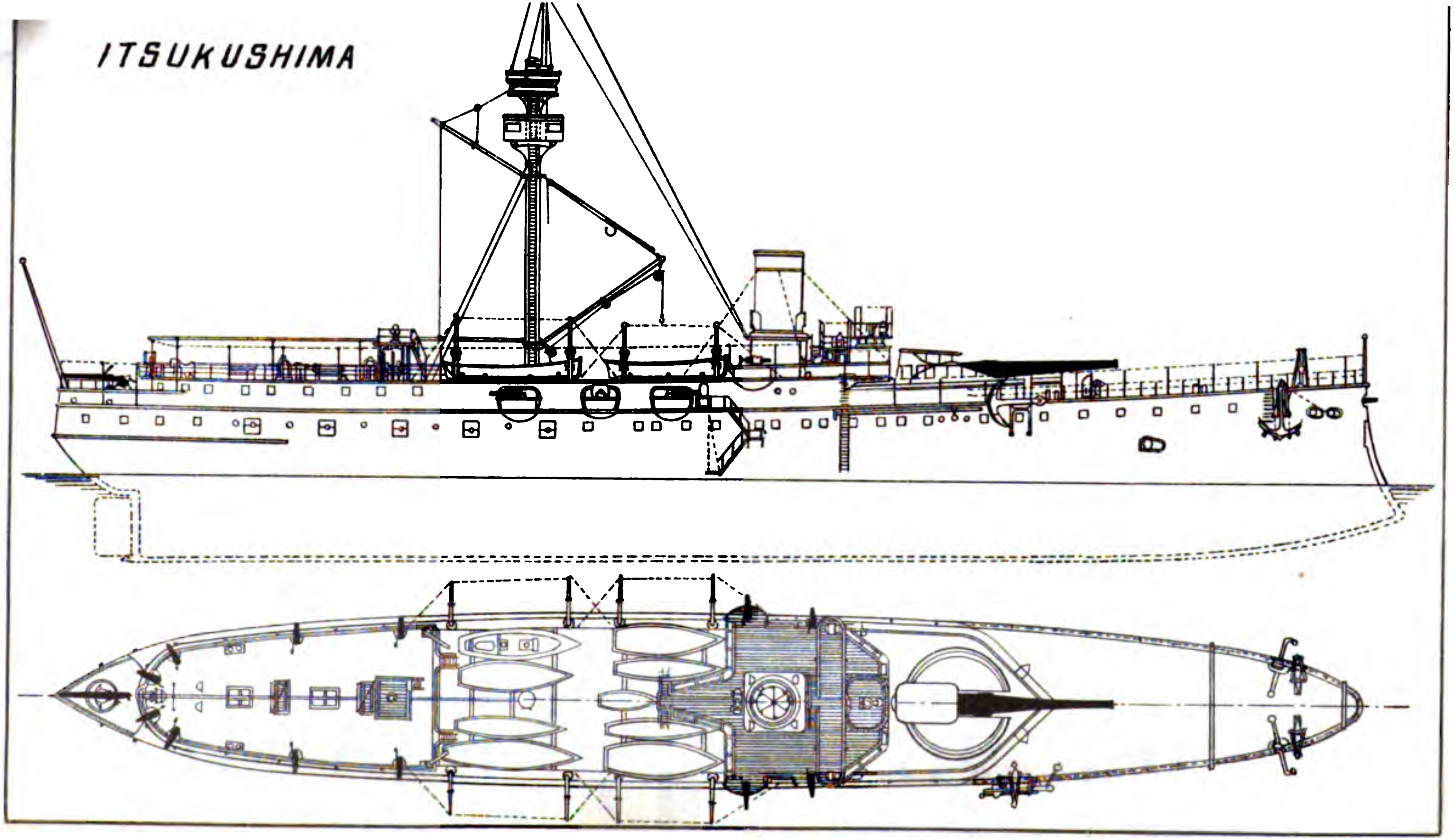
Four-inch steel shields cover the breeches of the heavy guns. (See Steam trials.)

DAI-ICHI (NO. 1) SASEPO.

A steel torpedo, and mine carrying vessel was launched from the Mitsu-Bishi dockyard at Nagasaki in November, 1890, for use at the Sasepo Naval Headquarters.

Her dimensions: are length, 122 feet 6 inches; beam, 20 feet 6 inches; depth, 13 feet; displacement, 250 tons; speed, 11 knots.

ITSUKUSHIMA



STEAM TRIALS.

ITSUKUSHIMA.

Coast defense vessel of 4,277 tons (page 278, No. VI, and page 49, No. IX) has given great satisfaction. On September 25, 1890, a natural-draft trial gave 15.72 knots, and on October 15 a 4-hour run under forced draft gave 16.78 knots with a coal consumption of 170 kilos per square metre of grate surface, although 200 kilos were allowed and only 16 knots required. The engines worked perfectly on both occasions.

A trial to obtain the coal consumption at reduced speed took place a few days afterwards and lasted 12 hours. With 660 I. H. P., about one-ninth of the maximum power, the ship ran at a speed of 9.3 knots and the coal consumption amounted to 1.49 pounds per hour and per I. H. P.

CHISIMA.

Preliminary trials in April of this year gave nearly 20 knots with only 270 revolutions.

TORPEDO BOATS.

Six first-class boats are in course of construction or recently completed. They were of the French 35-metre type, but since the loss of two of these boats their designs have been given modifications which are said to be identical with the changes made in French boats of this class.

VESSELS LOST OR STRUCK FROM THE LIST.

Azuma, armored gunboat; *Chyodo-Kata*, *Raiden*, wooden gunboats, sold to private parties. *Moshun*, composite gunboat, transferred to the Department of Communications.

SWEDEN.

The Naval Budget for 1891 amounts to $2,124,927. The following sums are set apart for the construction of new ships:

To complete the armor-clad *Göta*, $133,650. To commence an armor-clad of the *Svea* class, $135,000. For one second-class gunboat, $65,880.

STEAM TRIALS.

GÖTA.

Coast-defense armor-clad of 3,100 tons (page 325, No. VII), had trials last Autumn at Gothenburg. A mean speed of 16 knots was obtained with 3,200 I. H. P.

PORTUGAL.

VESSELS PROPOSED OR LAID DOWN.

Messrs. Orlando Brothers, of Leghorn, were successful in the competition (page 52, No. IX), and it is understood that they are to receive contracts to build all four of the proposed belted cruisers as soon as the necessary money is voted by the Portuguese parliament.

The principal characteristics of these armored cruisers as designed by the Italian firm are: Length, 334.6 feet; beam, 46.9 feet; depth, 31.5 feet; draft, 20 feet; displacement, 4,700 tons; I. H. P., 11,000; speed, 21 knots; coal supply, 850 tons; steaming radius, 5,100 miles; maximum thickness of armor, 4 inches.

The four vessels are all to be delivered within 54 months from date of contract, and are to cost $1,127,520 apiece.

The Portuguese Government will acquire, when circumstances permit, the following gunboats for police and fiscal service on the rivers and coasts of their colonies in Africa: For the Province of Guinea one steamer of the *Massabi* type, to carry four rapid-fire and one machine-gun; and two launches, each armed with one rapid-fire and one machine-gun.

For the Province of Angola, two steamers of the *Massabi* type (220-ton gunboat), armed as above, and four launches.

For the Province of Mozambique, three steamers with the same armament as the *Massabi;* four steamers of the *Mosquito* type, each armed with two 2.9-inch R. F. and two machine-guns; four launches, each with one R. F. and one machine-gun; and two launches (which can be taken apart) for the navigation of the upper Zambezi.

Several light-draught gunboats have been recently constructed by Messrs. Yarrow & Co. for the Portuguese.

They are to be sent to East Africa for service on the Pungwe River.

TORPEDO BOATS.

PLONGEUR.

A submarine boat, invented by Señor Fontes Pereira de Mello, has been thus described:

Cylindrical in shape, terminating forward in a cone; length, 72.1 feet; diameter, 11.5 feet; displacement, when completely submerged, 160 cubic metres of water.

There are two propellers actuated by electricity, which is stored in accumulators.

Estimated speed, 6 knots during 14 hours.

The submersion and rising of the boat are controlled by the admission or expulsion of water, and by an arrangement of horizontal rudders.

The interior is always in direct communication with the outer air, ventilators being fitted to supply 40 cubic-metres of fresh air per hour at any depth of submersion.

On top, about midway of the boat's length, is a small observation tower, with glass ports, and another visual apparatus similar to the périscope described on page 32, No. IX, is also fitted.

The armament consists of four dirigible torpedoes of the Nordenfeldt type, which are to have a radius of action of about 4,370 yards.

A committee has been appointed by the Portuguese Government to study the invention.

BRAZIL.

VESSELS PROPOSED OR LAID DOWN.

PERNAMBUCO, MARANHÃO.

Monitors for river service were laid down at the Arsenal of Rio de Janeiro on June 11, 1890.

VESSELS LAUNCHED.

CANANEA.

This light-draft gunboat was launched at the Arsenal of Rio de Janeiro on June 11, 1890.

Her armament will consist of six rapid-fire guns and one torpedo tube.

Motive power.—Two compound engines of 200 I. H. P., which are to give about 8 knots speed.

Dimensions.—Length, 115 feet; beam, 26 feet; draft, 4½ feet; displacement, 210 tons.

STEAM TRIALS.

Four steamers, specially designed for service as armed gunboats on the Amazon River, have recently been completed in England for the Brazilian Government.

Armament.—One 3-pounder, R. F. G., and two Nordenfeldt machine-guns.

Motive power.—One compound engine, contracted to give 10 knots speed with a full complement of stores, armament, crew (60 men), and other weights, including 7 tons of coal.

Dimensions.—Length, 90 feet; beam, 15 feet; depth, 7 feet 9 inches; draft in fresh water not to exceed 4 feet 11 inches when vessels are fully equipped and carrying a load of 33 tons.

Their hulls are built of galvanized steel, with decks, deck houses and fittings of East India teak.

The steam trials, which were conducted under Admiralty conditions, were most satisfactory, a mean speed of over 11 knots being realized with machinery working smoothly at the maximum power.

TORPEDO BOATS.

A new torpedo boat, which Messrs. Thornycroft have recently completed for the Brazilian Government, was given trials on June 2, of this year, which were eminently successful. . The vessel is 150 feet long by 14 feet 6 inches beam, and carries four torpedo-tubes fitted to use the 14-inch Whitehead. Two of these tubes are mounted on racers, on deck, and the other two, in the bows, are fitted to rig in and out through openings in the skin of the boat. The machinery consists of two sets of triple-compound engines, supplied with steam by two Thornycroft water-tube boilers. The trial consisted of two tests: (1) A series of six runs over the measured mile, with a load of 19 tons, during which a speed of 25 knots was guaranteed by the builders; and (2) a continuous run of 2 hours' duration, during which a speed of 24 knots was guaranteed.

The mean of the six runs, computed by the Admiralty method, was 25.858 knots, and the total distance run in 2 hours was 50.775 nautical miles, an average of 25.387 knots an hour. During the run, steam was blowing off from both boilers, and the pressure of 210 pounds was maintained with ease with an air pressure of only 1¼ inches.

ARGENTINE REPUBLIC.

VESSELS LAUNCHED.

NUEVE DE JULIO—INDEPENDENCIA,

Armored coast defense vessels (page 53, No. IX), have been launched by Messrs. Laird Brothers, of Birkenhead; the former on December 11, 1890, and the latter on February 26, 1891. They are to displace about 2,700 tons, and have engines of 3,000 horse-power. Their compound armor, which has been furnished by Messrs. Campbell & Co., will have a maximum thickness of 8 inches.

25 DE MAYO.

This protected cruiser, described heretofore as the *Nicochea* (page 53, No. IX), and also reported as being named the *Argentino*, has been christened the 25 *de Mayo*. She is of the *Piemonte* type, but larger, her dimensions being, length between perpendiculars, 325 feet; beam, 43 feet; mean draught, 16 feet; and displacement, 3,200 tons.

Armament.—Two 8.3-inch B. L., one forward and one aft; eight 4.7-inch R. F. G. on sponsons; twelve 3-pounder and twelve 1-pounder R. F. G., and three torpedo tubes.

Motive power.—Two sets of vertical 4-cylinder engines and four double-ended steel boilers; all completely below the water-line.

Protection.—A complete steel deck, is 3½ inches to 4½ inches thick on slopes, and 1¾ inches on the flat, which is 1 foot above water-line. Above this deck, and extending the entire length of the vessel, is a raft body, 3 feet deep along the midship portion and of greater depth towards the extremities, where the protective deck slopes downwards. Along the sides of the ship, in wake of the machinery, coal bunkers are constructed so as to form a continuation of the raft body, and these and the raft body are divided into numerous water-tight compartments. The principal hatchways are protected by 5-inch glacis and cofferdams.

In other respects the vessel is similar to the fast cruisers constructed, or in course of construction for the British navy, except that in the 25 *de Mayo* there is no inner bottom under the boiler compartments.

The normal coal supply is 300 tons; but 600 tons is the total bunker capacity, which gives a steaming radius of 10,000 miles at 10-knots speed and 2,000 at 21 knots.

The 25 *de mayo* has made 22.4 knots, the best speed on record for a ship of her size (see steam trials), and her gun trials have also been most successful.

The heavy guns were trained with ease and rapidity and the ship's structure withstood the strains of firing perfectly.

The method of sending up ammunition for rapid-fire guns seems worthy of mention: an endless leather band, furnished at intervals with hooks, reaches from the handing room of the magazine to the main deck, and is stretched over drums at top and bottom; one of these drums is rotated by means of a winch handle, and one or two men can thus send up a continuous stream of ammunition.

STEAM TRIALS.

25 DE MAYO.

The official trials occurred in November 1890 on the admiralty measured mile at the mouth of the Tyne. The trials included a run of 6 hours' duration with natural draft, and the mean speed was obtained by taking the total number of revolutions of the screws, obtaining therefrom the mean number of revolutions per minute, and applying these to a curve of performance previously obtained from runs with and against the tide at various speeds on the measured mile course. The actual performance was 21.237 knots per hour. The mean power developed during the 6 hours was 8,700 I. H. P. (contract 8,500) and the mean number of revolutions 144.9.

The forced-draft trial was made at the close of a long day's steaming; runs over the mile with and against the tide gave a mean speed of 22.43 knots, with 160 revolutions and 13,800 I. H. P. (contract 13,500).

ROSALES—ESPORA.

Torpedo vessels (page 53, No. IX) obtained the following very good results in trials which took place during November and December, 1890:

Rosales.—Steam pressure, 145 pounds; air pressure, 2.5 inches; vacuum, 29 inches; revolutions, 334; I. H. P., 3,532; speed, 19.76 knots.

Espora.—Steam, 150 pounds; air, 2.6 inches; vacuum, 26.5 inches; revolutions, 312; I. H. P., 3,448; speed, 19.823 knots.

These vessels are of the English *Rattlesnake* type, with forecastles and poops about 60 feet long. The side plating is ½ to ⅝ inch thick with a double strake in wake of machinery and boilers; no midship keel, but two bilge keels; conning tower, 1 inch steel, with search-light on top; 8 transverse and 1 longitudinal bulkhead and 12 principal water-tight compartments, in all 42 compartments; 5 feet freeboard amidships; coal protection; shields over all guns.

The machinery consists of two sets of triple expansion engines; cylinders 19, 28½, and 42, by 19½ inches stroke. There are four steel locomotive boilers fitted with steel fire boxes of a total grate-surface of 140 square feet, and heating-surface 5,415 square feet, to supply steam at 150 pounds pressure.

The normal coal capacity is 100 tons, and the total amount that can be carried is 130 tons, estimated to give a steaming radius of 2,800 miles at 10 knots.

A third vessel of this type is in course of construction at the works of Laird Brothers at Birkenhead.

TORPEDO-BOATS.—STEAM TRIALS.

COMODORO PY—MURATURE.

First-class sea-going torpedo-boats (page 54, No. IX) have given great satisfaction on their trials.

The first-named boat attained a speed of 25.06 knots on the measured mile and 24.2 knots on a run of 2 hours' duration, in each case slightly exceeding the guarantied speed of 25 knots on the measured mile and 24 knots on the 2 hours' run.

The *Murature* has also done very well, but details of her trial have not yet been noticed in public prints.

These boats are similar to the Spanish *Ariete* and the French *Coureur*, having the following dimensions: Length, 150 feet; beam, 14 feet 6 inches; displacement, 120 tons.

They are propelled by triple compound engines supplied with steam by two Thornycroft water-tube boilers.

The six first-class Yarrow boats (page 54, No. IX) are completed. Their armament consists of one 18-inch bow-tube and two 18-inch divergent tubes on a turntable aft. Also, two 3-pounder R. F. G. and one 1-inch Nordenfeldt R. C.

The first five are fitted with triple-expansion engines and locomotive boilers, which on trial have given the following satisfactory results: Mean speed on a 2 hours' continuous run, fully equipped, 23.08, 23.56, 23.37, 23.37 and 23.18 knots, respectively. The average steam pressure per boat was 170 pounds, and the I. H. P. 1,120.

The sixth boat, christened *Bathurst*, is similar in dimensions to the above five, but is fitted with quadruple-expansion engines.

The chief object in placing quadruple-expansion engines in the *Ba-*

thurst was to reduce the vibration, and a very fair measure of success was obtained in this direction, as well as a decided increase of power and speed.

The following table gives the principal data of an official trial which took place in the river Thames on November 13, 1890:

Steam in boiler.	Vacuum.	Air pressure in fire room.	Revolutions per minute.	Speed.	Mean speed.	Second mean.	True mean.
Pounds.	*Inches.*	*Inches.*		*Knots.*	*Knots.*	*Knots.*	*Knots.*
199	23.7	3.3	432	24.000	....	....	....
200	23.5	3.0	432	25.174	24.587	24.469	....
200	23.5	3.2	431.4	23.529	24.351	24.395	....
200	23.2	3.0	341	25.352	24.440	24.402	24.453
200	23.0	3.4	436.3	23.376	24.304	24.547	....
200	23.2	3.0	439	26.086	24.731	....	....

The I. H. P. was 1,230 a gain of 110 over the other boats.

The eight third-class boats, mentioned on page 54, No. IX, as having been ordered of Yarrow, are fitted with triple-expansion surface-condensing engines capable of indicating 250 I. H. P. and a new type of boiler which has given most satisfactory results.

They have all been tried and the mean speed obtained was about 17¾ knots, which is three-fourths of a knot above the average for boats of this type (15 tons) fitted with locomotive boilers.

The following table gives the result of a trial of one of these boats that took place on December 23, 1890:

Steam.	Vacuum.	Air.	Revolutions per minute.	Speed.	First means.	Second means.
Pounds.				*Knots.*		
170	23	2.7	570	19.672	....	....
170	23	3.2	577	15.859	17.765	....
170	22.7	3.5	568	19.890	17.909	18.021
171	22.5	3.3	680	15.929	18.133	18.098
172	22.7	3.2	597	20.388	18.063	18.121
172	23	3.6	578	15.789	18.180	18.215
174	22.5	3.1	582	20.571	18.250	....
173	23	3.4	583	15.929	....	....
172	22.7	3.35	578	....	....	....

Admiralty mean, 18.113 knots.

TURKEY.

TORPEDO-BOATS.

Several 39-metre and 47-metre boats have been completed by Schichau during the last year and sent to Constantinople.

VESSELS LOST OR STRUCK FROM THE LIST.

Ertogrul.—Old type steam frigate. Lost off the coast of Japan in September, 1890.

MEXICO.

VESSELS LAUNCHED.

SARAGOSA.

School-ship (page 55, No. IX) was launched at Havre on April 9, 1891.

Her principal characteristics are:

Length, 213.2 feet; beam, 32.8 feet; depth, 18 feet; draught, 14.1 feet; displacement, 1,200 tons.

Engines of 1,300 horse power are to give 13 knots speed.

Armament.—Two 4.72-inch breech-loaders and four R. F. G.

Complement, 230 (including cadets). Bark rig.

EGYPT.

VESSELS LAUNCHED.

AB-BASS.

The Ailsa Shipbuilding Company launched on March 28, 1891, a "screw steam dispatch cruiser" of the above name for the Egyptian Government.

Her dimensions are: Length, 175 feet; beam, 22 feet; depth, 13 feet 9 inches. She will be fitted with triple-expansion engines by Messrs. Muir and Houston, and is to have an installation of electric lights, including a search light. She is intended for service in the Red Sea.

SALVADOR.

A small wooden steamer named the *Cuscatlan* has been built at San Francisco for the Salvadorean Government. It is reported that she is to be armed and employed in the revenue service of that country, or possibly as a man-of-war.

Her dimensions are: Length, 86 feet; beam, 18 feet; draught, 7½ feet; displacement, 75 tons.

Triple-expansion engines; steel boilers; speed, 10 knots. Cost, about $25,000.

VENEZUELA.

Four gunboats have been recently ordered in England for the Venezuelan Government.

CHARLES E. FOX,
Lieutenant, U. S. Navy.

II.

NOTES ON MACHINERY.

MACHINERY FOR UNITED STATES VESSELS.

The following information regarding machinery for United States vessels contracted for, or the construction of which has been authorized by Congress during the past year, is taken in part from the report of the Chief of the Bureau of Steam Engineering for 1890, and in part from specifications issued by the Bureau:

Coast-line Battle-ships Nos. 1, 2, *and* 3 (*Indiana, Massachusetts, and Oregon.*—These ships are to be propelled by engines capable of developing, when forced, 9,000 I. H. P., and under ordinary conditions, 8,000 I. H. P., driving twin screws. The main engines are to be inverted, vertical, direct-acting, triple-expansion, with cylinders of 34½, 48 and 75 inches in diameter, and 42 inches stroke, and it is estimated that at a piston speed of 900 feet per minute, or 129 revolutions, the collective I. H. P. of propelling, air-pump, and circulating-pump engines will be 9,000. Each engine and its auxiliaries is to be separated from the other by a fore-and-aft water-tight bulkhead. The high-pressure cylinder of each engine is to be forward and the low-pressure cylinder aft. The main valves are to be of the piston type, worked by Stephenson double-bar links, one valve for each high-pressure cylinder, two for each intermediate, and four for each low-pressure cylinder, the diameter of all the valves to be 17 inches, and the valve gear of the intermediate-pressure and low-pressure cylinders to be interchangeable.

The cylinders are to consist of casings of cast-iron of the best quality, with working linings; the intermediate and low-pressure cylinders are to be steam-jacketed at sides and bottom, the high-pressure ones unjacketed; cylinder covers to be of cast-iron. The framing is to consist of one inverted Y-column at the back of each cylinder and two forged-steel cylindrical columns at the front. The engine bed-plates are to be of cast-steel, supported on wrought-steel keelson-plates built in the ship.

Each main piston is to have one piston-rod, with a cross-head working on a slipper guide. The piston-rods, connecting-rods, valve-stems, and working parts generally, are to be forged of mild, open-hearth steel. The pistons are designed to be of cast-steel. Eccentrics are to be of cast-iron, each in two parts.

All crank, line, and propeller shafting is to be of mild forged-steel. The crank-shafts are to be in three sections, reversible and interchangeable with each other and with those of the other engine. They are to be 14 inches in diameter in the journals and 15 inches in the pins, with axial holes of 6 inches diameter through the former and 6½ inches through the latter. The crank-pins are to be 17 inches long, the crank-shaft journals 16½ inches long. The line shafting for each engine is to be in two sections about 19 feet long, of 13¾ inches diameter, and with 6-inch axial holes. The thrust-shafts are to be about 19 feet long, and of 13¾ inches diameter, with 6-inch axial holes, each shaft with 11 thrust-collars of 18¾ inches outside diameter. The propeller-shafts are to be each in one section, about 39 feet long over all, 14 inches in diameter, and with 6-inch axial holes.

Each engine is to have a separate condenser, made with cast-brass heads and rolled-brass shell, bolted and riveted together. The castings are to be $\frac{7}{16}$ inch thick, and are to contain all the nozzles for steam and water openings. The shell is to be of ¼-inch plates, butted strapped, riveted, and soldered together. The diameter is to be 5 feet 9 inches, and the length between tube-sheets, 10 feet 3 inches. Each condenser is to contain 3,788 seamless-drawn brass tubes, of ⅝-inch outside diameter, giving 6,353 square feet of cooling surface, measured on the outside.

The circulating pumps, two in number, one for each engine, are to be independent pumps of the centrifugal type, with both sea and bilge connections. Each pump is to be capable of discharging 9,000 gallons of water per minute.

The air pumps, two for each engine, are to be vertical, single-acting, lifting pumps, of 20 inches diameter and 18 inches stroke. Owing to the difficulty experienced in running air pumps at low speed when the rods are directly attached to the driving engines, these pumps are designed to be driven by gearing, the driving engines making 2½ revolutions to each double stroke of the pumps. The smaller spur-wheels used are to be made of rawhide, to lessen the noise when working. The cylinders of the air-pump engines are to be of 6 inches diameter and 12 inches stroke, and are to exhaust into either receiver, or into the condenser, at will. The pumps are to be entirely of composition.

Each engine-room is to have an auxiliary condenser, made of composition and sheet-brass, of sufficient capacity for one-half the auxiliary machinery, with connections to all the auxiliary machinery. Each of these condensers is to have a combined air and circulating pump.

There are to be four main and two auxiliary boilers, of the horizontal, return fire-tubular type, made of mild steel, and intended for a working pressure of 160 pounds. The main boilers are to be of 15 feet outside diameter and 18 feet long, double-ended, and with shells $1\frac{19}{64}$ inches in thickness. Each main boiler is to contain eight corrugated steel furnaces of 3 feet internal diameter. The tubes are to be of steel, lapwelded or seamless-drawn, of 2½ inches outside diameter, the ordinary tubes No. 12 B. W. G. and the stay-tubes No. 6 B. W. G. in thickness. The main boilers are to have about 17,460 square feet of heating surface and about 552 square feet of grate; they will be placed in four watertight compartments. There are to be two smoke-pipes. The auxiliary boilers will be placed above the protective deck; they are to be single-ended, of about 10 feet 2 inches outside diameter, and 8 feet 6 inches long. Each auxiliary boiler is to contain two corrugated steel furnaces of 2 feet 9 inches internal diameter. The heating surface for the two auxiliary boilers is to be about 1,937 square feet, and the grate surface 64 square feet.

The forced draft system is to consist of one blower for each fire-room for the main boilers, and one for each fire-room for the auxiliary boilers, discharging into closed fire-rooms. Air-tight bulkheads are to be fitted to reduce the space to be maintained under pressure.

There are to be in each fire-room one main and one auxiliary feed pump, with an additional auxiliary feed pump in each engine-room, the whole capable of supplying many times the quantity of water needed at full power.

There are to be evaporators, distillers, auxiliary pumps, blowers for draft and ventilation, and the other auxiliaries now furnished ships of this class, together with the necessary hydraulic plant for loading and handling the battery.

The propellers are to be manganese-bronze, or approved equivalent metal, with adjustable blades.

Cruiser No. 12.—The motive machinery of this vessel, which is intended to make 21 knots, is designed to develop a collective I. H. P. of 20,000 or 21,000. The engines are to have cylinders of 42, 59, and 92 inches diameter, with 42 inches stroke, and are to be precisely similar to those of Cruiser No. 6 (of 5,500 tons), described in General Information Series, No. IX., 1890, except that the air pumps are to be different, and that three engines are to be employed instead of two.

The air pumps, two for each engine, are to be vertical, single-acting, lifting pumps of 22 inches diameter and 20 inches stroke. They are to be driven by two simple engines with cylinders of 7 inches diameter and 12 inches stroke, arranged to exhaust into the condenser or into either receiver. The driving engines are to be geared to make 2½ revolutions to each double stroke of the pumps.

There are to be eight double-ended main boilers and two single ended auxiliary boilers, of the horizontal, return fire-tubular type, all built of mild steel. Six of the double ended boilers are to be of 15 feet 9 inches outside diameter, and 18 feet long, with eight corrugated furnaces of 3 feet 3 inches internal diameter. Two of the double-ended boilers are to be of 15 feet 3 inches outside diameter and 18 feet long, with eight corrugated furnaces of 3 feet 3 inches internal diameter. The single-ended boilers are to be of 10 feet 1$\frac{25}{32}$ inches outside diameter and 8 feet

6 inches long, with two corrugated furnaces of 2 feet 9 inches internal diameter. The auxiliary boilers will be placed above the protective deck. The main boilers are arranged in groups of two, in four separate water-tight compartments, with five athwartship fire-rooms and three smoke-pipes. Forced draft on the closed fire-room system is to be used, with centrifugal fan blowers for each fire-room. There are to be one main and one auxiliary feed pump in each fire-room, and one auxiliary feed pump in each engine-room.

There are to be evaporators, distillers, reversing and turning engines, fire and bilge pumps, ice machine, steam ash-hoists, capstan engine, and all the other auxiliaries fitted in modern ships.

Referring to the comparative novelty of the design of the machinery of this vessel, lying in the adoption of triple screws, the Engineer-in-Chief, in his latest annual report, says:

> Knowing that it was extremely improbable that shafting of the great size necessary to transmit this enormous power to twin-screws could be obtained in this country, either in reasonable time or with any guaranty as to its strength, the Bureau decided to depart from the usual practice and to divide the power into three parts instead of two, each being developed by a separate engine driving its own screw. It was still further influenced to do this by the knowledge that even in case of the recurrence of so remarkable an accident as that which lately happened to the *City of Paris*, this cruiser would still have a reserve of power sufficient to drive her at a good rate of speed. Indeed it is almost impossible to conceive a combination of circumstances or accidents that would render her entirely helpless.
>
> A feature of the design that carries a strong argument in its favor is that by means of clutch-couplings either propeller can be disconnected from its engine and left free to revolve, thus retarding the way of the ship but very slightly when she is being propelled by one or two engines. A still further advantage is that in moderate cruising, say with one-third power, a few boilers can be used with the high steam pressure for which they are intended and one engine driven at the full power for which designed; by this means the power will be obtained economically instead of wastefully, as is the case when a large engine is run at a low power. It is estimated that with one-third power and one screw the ship can be driven about 15 knots; with two screws and two-thirds power, from 18 to 19, the screws not in use being allowed to revolve freely in either case.
>
> There is but little information at hand in regard to propulsion by three screws. A number of torpedo cruisers having them are built or building for the Italian navy and a cruiser of 6,000 tons so fitted is now being built in France. A number of experiments were also made with them in the latter country on the launch *Carpe*. It is not supposed by the Bureau that three screws will prove a more efficient mode of propulsion than two; on the contrary, it believes that except for the highest power they will prove slightly less efficient, but its reasons for adopting them have already been given.
>
> * * * * * * *
>
> In the experiments with the *Carpe*, referred to, it was found that when the three propellers were placed abreast of each other the efficiency of the center one was greatly impaired by the interference of the side ones with the water flowing to it. For this reason the side propellers have been placed in this cruiser about 15 feet forward of the centre one, thus avoiding as much as possible working the latter in the race of the former. It will also be noticed that, looking at the ship from aft, the propellers are not in the same horizontal line, but that the side ones are placed as high as their diameters will permit; also that to bring these propellers clear of the

ship's sides the side shafts incline outwards from the centre line of the ship 4 degrees and also slightly upwards. The shaft of the centre propeller is in the central longitudinal plane of the ship and inclined slightly downwards.

The central screw will have four blades and about 10 per cent. more pitch than the side ones, as it will work in more or less disturbed water. The side screws will be three-bladed, and the blades of all the propellers will be adjustable and will be set to the pitch on trial found to be most efficient.

Cruiser No. 13.—The machinery of this vessel is to be, except in some minor details, almost an exact duplication of that of Cruiser No. 12. The only changes of any consequence will be in the arangement of fire-rooms, the dimensions of the boilers, and the substitution of two smoke-pipes for three. The boiler space is divided into four water-tight compartments, the same number as in Cruiser No. 12, but the division is effected by one athwartship and one fore-and-aft bulkhead, instead of by three athwartship bulkheads. The length of the boilers of 15 feet 9 inches diameter is increased from 18 feet to 20 feet, and that of the boilers of 15 feet 3 inches diameter to 18 feet 1¾ inches. The corrugated furnaces of the boilers of 15 feet 9 inches diameter are increased in internal diameter from 3 feet 3 inches to 3 feet 4 inches. The auxiliary boilers are unchanged. The total heating surface for all the boilers will be 49,248 square feet, and the total grate surface 1,522 square feet.

Harbor-defense Ram.—The motive machinery for this vessel has been designed to give her a speed of 18 knots on a displacement of 2,050 tons.

There will be two horizontal, direct-acting, triple-expansion engines, driving twin screws. The cylinders will be 25, 36, and 56 inches in diameter, with a common stroke of 36 inches; the I. H. P. is estimated at 4,800 (with auxiliaries) when making 150 revolutions per minute.

Each engine with its auxiliaries will be entirely independent of the other, and in a separate water-tight compartment.

The main steam-valves will be of the piston type, and there will be one for each high and intermediate and two for each low-pressure cylinder, having diameters of 12, 21½, and 21½ inches, respectively. They will be driven by the Marshall radial gear with compensating rock shafts. All this valve gear, except the rockshafts, will be interchangeable.

The engine keelsons will be built in the ship, and the cylinders will be cast with brackets attached, by which they may be bolted together and to the engine keelsons; in addition, the cylinders will be attached by forged-steel tie-rods to the bed-plates and engine frames.

There will be one forged-steel piston-rod for each engine, with a cross-head working on a cast-iron bar guide; the valve-stems will be made of forged-steel; the pistons will be of cast-steel, fitted with a wide cast-iron shoe in the high-pressure cylinder, and with a similar shoe lined with white metal in the intermediate and low-pressure cylinders.

The crank-shafts will be in two sections for each engine; they will be made of mild forged-steel, 10¾ inches in diameter in the journals and 11 inches in the crank-pins; there will be axial holes 5 inches in diameter through shafts and pins.

The condensers will be made of cast composition and rolled sheet-brass, the composition parts containing the nozzles for the exhaust, bleeder, air and circulating pumps, etc. The condensers will be of 4 feet 11 inches diameter inside, and 7 feet in length between tube-sheets. The circulating water is to pass through half of the tubes and return through the other half. The tubes will be of ⅝-inch outside diameter, No. 20 B. W. G. thick, and each condenser will contain 2,935, giving about 3,361 square feet of cooling surface. The shells will be made by riveting the sheets together and then soldering the joints. There will be deflecting plates in the steam space to distribute the steam over the cooling surface. Each tube will be packed at each end and left free to expand but prevented from crawling.

The air and circulating pumps will be selected from designs submitted by manufacturers making a specialty of such work; they will consist of two vertical, single-acting, lifting air pumps, and one horizontal, double-acting circulating pump, all driven by a single direct-acting engine.

The boilers are intended for a working pressure of 160 pounds per square inch. As originally designed by the Bureau of Steam Engineering, these were four in number, of the straightway fire-tubular type, 11 feet 6 inches in diameter and 19 feet 3 inches long, each containing three corrugated steel furnaces of 3 feet 8 inches internal diameter. The contractors (the Bath Iron Works) have submitted alternative designs, which have been approved by the Bureau of Steam Engineering, and the construction of the boilers upon the new designs has been authorized. The boilers proposed are two double-ended Scotch boilers of 13 feet 6 inches diameter and 22 feet 6 inches in length, each containing six corrugated furnaces of 3 feet 6 inches internal diameter and 8 feet in length, and one single-ended boiler of 13 feet 6 inches diameter and 11 feet 6 inches in length, containing three corrugated furnaces of 3 feet 6 inches internal diameter and 8 feet in length. The grates are to be 6 feet 9 inches in length, giving a grate surface of 141.6 square feet for each double-ended boiler and 70.8 square feet for the single-ended boiler. Each double-ended boiler will have 828 tubes of 2¼ inches diameter, and the single-ended boiler 414.

The ratio of heating surface to grate surface will be 34.3 in each case. The total heating surface for all the boilers will be 12,150 square feet, and the total grate surface 354 square feet, as compared respectively with 10,797 square feet and 288 square feet in the original design. The weight of each double-ended boiler is 57.5 tons, and of the single-ended boiler 32 tons; with water these weights become respectively 97 tons and 52 tons. Comparing weights of boilers, water, grates, uptakes, and pipe with the same weights in the original Bureau design, the total amounts to about 267 tons in each case.

All boiler-plate will be of mild, open-hearth steel; the rivets will be made by open-hearth or Clapp-Griffith process.

The boilers will be placed in two water-tight compartments, with athwartship fire-rooms. Forced draft will be on the closed fire-room system, and each fire-room will be supplied with blowers of ample size.

There will be one main and one auxiliary feed pump in each fire-room, and one auxiliary feed pump in each engine-room, the system being capable of supplying many times the maximum quantity of water required by the boilers.

The auxiliaries will comprise evaporators, distillers, reversing and turning engines, auxiliary pumps, ventilating and forced-draft fan blowers, ash-hoists, electric-light, steering, and anchor-hoisting engines, and workshop machinery.

The propellers will be of manganese-bronze, three-bladed, built up so that the pitch may be altered, or, if a blade be broken, it may be replaced without removing the screw.

Proposed Torpedo-cruiser, No. 1.—Bids for the construction of this vessel were advertised for, but none were offered, either for hull or machinery.

The specifications called for triple-expansion engines, rights and lefts, driving twin screws, each engine having cylinders of 23¾ inches, 34¼ inches, and two of 38 inches diameter, with a common stroke of 18 inches. It was estimated that the collective indicated horse power should be about 6,000, and that this should be sufficient to drive the vessel, of 750 tons displacement, at a speed of 23 knots. The engines were designed to make 333 revolutions per minute.

The condenser was designed to have a cooling surface of about 8,400 square feet, and to be fitted with two vertical, single-acting air pumps for each engine, worked from the low-pressure cross-heads. Independent centrifugal circulating pumps were designed.

The boilers specified were eight water-tube boilers, constructed for a pressure of 200 pounds per square inch, placed in two water-tight compartments, and working with forced draft on the closed fire-room system. Three smoke-pipes were to be provided.

In addition to the main engines, various auxiliary engines were called for by the specifications, and it was provided that the total weight of all machinery and boilers, including water in the boilers, condensers, and pipes, and with feed tanks two-thirds full (but not including stores, spare parts, heaters, steering gear, and capstans) should not exceed 255 tons.

Torpedo-boat No. 2.—Bids were advertised for, June 19, 1891, and are to be opened, Aug. 26, 1891.

The specifications of the Bureau design call for two sets of four-cylinder quadruple-expansion engines of the vertical, inverted, direct-acting type, operating twin screws. The cylinder diameters are to be 11½, 16, 21½, and 30 inches, and the stroke of all pistons, 16 inches. The estimated I. H. P. of propelling and circulating pump engines is 1,800, based upon a propeller speed of 412 revolutions per minute. The cylinders are to be arranged in order, with high-pressure cylinders forward and low-pressure cylinders aft. Both engines are to be contained in a common water-tight compartment. The main valves are to be operated by Stephenson link-motions. There will be one piston valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and one double-ported slide-valve for each low-pressure cylinder. Cylinders and cylinder-casings are to be of hard cast-iron, bolted together by body-bound, forged-steel bolts. Cylinder covers and valve chest covers are to be of cast-steel, pistons of cast or forged steel, valves of cast-iron. Eccentrics are to be of cast-steel, in two parts, eccentric straps of composition, fitted with white metal. Piston-rods, connecting rods, cross-heads, eccentric-rods, and valve-stems are to be of forged open-hearth steel, piston-rods and connecting-rods to be oil-tempered.

The engine framing is to consist of forged-steel columns trussed by forged-steel stays. The condenser is to be of composition and rolled brass, with a cooling surface of about 1,379 square feet measured on the steam side of the tubes, the outside. There is to be one single-acting air-pump for each engine, worked by eccentric from the main shaft. The circulating pump is to be of the centrifugal type, worked by a vertical single-cylinder engine of 5 inches diameter and 3½ inches stroke. The main feed pumps are to be vertical, single-acting, plunger pumps, worked by worm-gear from the main shafts, geared to make one stroke to four of the main engines. All shafting is to be of forged-steel; the crank-shaft of each engine to be of 5 inches diameter, with an axial hole of 2½ inches diameter drilled through it; the thrust-shaft to be solid, of 4⅝ inches diameter, with 8 collars of 7¾ inches diameter; the propeller-shaft to be solid, of 4¾ inches diameter. All crank-pins are to be 8 inches long and 5 inches in diameter, with axial holes of 2½ inches diameter. Stern-tube and stern-bracket bearings are to be of white metal, screw propellers of manganese-bronze.

The boilers are to be of the tubulous type, two in number, in separate water-tight compartments. They are to be constructed for a steam pressure of 250 pounds, and are to be operated with forced draft on the closed fire-room system, with one blower for each fire-room. There are to be two smoke-pipes. An auxiliary feed pump is to be provided in each fire-room. Evaporators and distillers are to be fitted.

The weight of all machinery and boilers, including auxiliary machinery, and including water in boilers, condensers, and pipes, but not including stores, spare parts, heaters, steering gear, and capstans, is not to exceed 53 tons.

AUTHORIZED CHANGES IN FORMER DESIGNS.

The following changes, with others of lesser importance, have been made in machinery heretofore described:

Newark.—Auxiliary air and circulating pumps have been introduced and an auxiliary condenser.

Bennington and Concord.—The diameters of the steam cylinders of air and circulating pumps have been increased from 12 inches to 14 inches.

Maine.—Forged-steel engine columns have been adopted on account of the difficulty experienced in getting cast-steel ones made. Cast-iron has been substituted for cast-steel as material for steam-chest covers. The forward coupling sleeve is to be made of forged-steel instead of cast-steel.

Monterey.—Phosphor-bronze has been substituted for cast-steel for reversing-shaft bearings. Eccentrics are to be made of forged-steel instead of cast-steel. The original design of air pump has been abandoned and Dow's air pump substituted. Ward boilers have been adopted to furnish three-fourths of the boiler power.

Cruisers Nos. 7 *and* 8.—The contractors for steel castings for engine columns, after repeated unsuccessful attempts to secure serviceable castings, informed the Bureau of their inability to make the columns. Steps have been taken to have the columns made of cast-iron.

Gunboats Nos. 5 *and* 6.—Cylinder heads to be made of cast-iron instead of cast-steel.

The contractors for these vessels have submitted an alternative design for the boilers, which has been approved by the Bureau of Steam Engineering, and their construction has been authorized. These boilers are to be of locomotive type instead of the straightway type originally designed. The following table exhibits comparatively the particulars of the two designs:

	Original, straightway.	New, locomotive.
	Square feet.	*Square feet.*
Heating surface, tubes	1,605	2,043
Heating surface, furnaces	108	194
Heating surface, combustion chamber	102	71
Heating surface, total	1,815	2,308
Grate surface	50	60
Ratio, H. S. to G. S	36.3	38.5
	Tons.	*Tons.*
Weight of boilers	21	22½
Weight of water	14	11
Weight, total	35	33½

These particulars refer in each case to one boiler. There are to be two of the locomotive boilers in each vessel, of the following general dimensions: total length, 18 feet 6 inches; length of tubes, 8 feet; diameter of cylindrical portion, 9 feet 1¼ inches; maximum width, 10 feet 5 inches; maximum height, 10 feet 2½ inches; number of tubes, 488; diameter of tubes, external, 2 inches.

Cruisers Nos. 9 *and* 10.—The main boilers are to be made of four rings instead of three, and the auxiliary boilers of two rings instead of one, to allow the use of a power riveter.

Cruiser No. 11.—Cross-heads to be of wrought-steel instead of cast-steel. The contractors have been given permission to substitute built-up, wrought-steel engine columns in place of the cast-steel ones designed, they having reported their inability to obtain the castings.

Armored Cruiser No. 2 (*of* 8,100 *tons*).—The diameter of the L. P. cylinder is increased from 70 inches to 72 inches. Forged-steel is to be used instead of cast-steel for cross-heads. The main boilers are to be made 15 feet 9 inches in diameter and 18 feet in length, instead of 15 feet 3 inches in diameter and 21 feet 3 inches in length.

Steel castings.—It will be observed that many of the changes noted consist in the substitution of other metals for cast-steel where that material has been called for in the original specifications. In this connection the following paragraph is quoted from the report of the Chief of the Bureau of Steam Engineering:

> In my report for last year attention was called to the ill success that had attended numerous attempts to use steel for machinery castings, and the experience of the past year has been to still further emphasize all that was then said. Reports have been received of failure after failure to produce sound castings of comparatively simple form and moderate weight and design, and patterns have been altered in the hope that better results might be obtained with change of form. In many cases the changes have availed nothing and after long delays application has been made to use forged-steel or cast-iron. In others, when the dimensions have been increased to nearly what would be required for the latter metal, sound castings have been obtained. The truth of the matter is that the manufacturers have not kept pace with the demands of the consumers, and unless there is a very great improvement in the making of steel castings, and in a very short time, a return to cast-iron will be inevitable, since it is evident that the only reason for using the more expensive material is that the weight of the parts may be decreased in the proportion of its greater strength.

ENGINES.

THE ACCIDENT TO THE S. S. CITY OF PARIS—JUDGMENT OF THE COURT OF INQUIRY.

A Board of Trade Inquiry into the causes of the accident which occurred to the propelling machinery of the Inman steamer *City of Paris*, March 23, 1890, was held at the Civil Court, St. George's Hall, Liverpool, June 16, 17, 18, and 19, 1890, and judgment was delivered June 24, 1890. The following is the full text of the finding, together with the questions, eighteen in number, submitted to the Court by the Board of Trade:

1. Whether in the construction of the vessel, her engines and machinery, full provision was made to insure her safety as an ocean-going steamer, and whether in any, and if so, in what respects the safety of the vessel was sacrificed to speed?

We are of opinion that full provision was made to insure every safety as an ocean-going steamer, and that the safety of the vessel was not sacrificed to speed.

2. Is cast-steel a proper and suitable material to be employed in the columns, bed-plate, and boxes of the bearings of the shaft, or either of the portions of the machinery?

We consider cast-steel to be a proper and suitable material to be employed generally in the construction of various parts of engines that have hitherto been made usually of cast-iron.

3. Was the shaft of the starboard engine properly and sufficiently supported throughout by bearings; was the after bracket properly constructed; and was it of sufficient strength, having regard to the length of the shafting and the propeller it had to support?

The inboard portions of the propeller shaft of the starboard engine are amply supported; and, judging from the present condition of the outboard portions of the propeller shaft of the port engine, the supports to the outboard portions of the propeller shaft of the starboard engine, which are of similar construction to those of the port one, would appear to have been sufficient. The after bracket in each case is properly constructed and is of sufficient strength for the shafting and propeller it had to support.

4. Were the bushes in the stern tube and after bracket of suitable materials and of proper construction?

The bushes in the stern tube and after brackets are of suitable materials. The construction, that is the method of securing the lignum-vitæ, is somewhat recent, and is said to be much used by Clyde and other engineers with satisfactory results. It is, however, to be observed that in the older and more generally adopted system of fitting, that is by placing each strip of lignum-vitæ in a suitably formed recess having gun-metal partitions between them, each strip is thus preserved in position and the waterways between them are larger and less liable to choke.

5. Were the shaft liners properly constructed; were they of suitable material; and were they properly fitted to the shaft?

The linings or casings were of suitable material, and the evidence we have heard proves that they were properly constructed and fitted to the ship.

6. Were the cylinders, piston-rods, connecting-rods, and all other parts of the machinery of the starboard engine of suitable material; was the material properly examined and tested; and were the starboard engines properly constructed?

The cylinders, piston-rods, connecting-rods, and other parts of the machinery of the starboard engines were generally of suitable materials, and the engines were properly constructed. The materials were tested in the usual manner to the satisfaction of the surveyors of the Board of Trade and of Lloyd's.

7. Whether suitable governors were provided?

Governors were provided for controlling the engines in a seaway. They were not connected when the accident of March 23rd occurred, and if they had been they could not have affected the results of it.

8. Were the bulkheads properly constructed, and were they of sufficient strength, independently of support from either shoring or cargo, for the purpose of insuring the safety of the vessel, assuming any two of the cargo compartments flooded at the same time in any state of weather; whether the longitudinal bulkhead between the engine-rooms was of a sufficient strength and carried to a sufficient height, and was it desirable that there should be a door in it below the water line?

The bulkheads were properly constructed, and from our personal inspection of the ship, and from the evidence that has been given respecting them, we are of opinion that they were sufficiently strong without shoring or cargo to stand the pressure that they may have been subjected to, assuming any two of the large compartments to be flooded at the same time, in any state of the weather. The longitudinal bulkhead between the engine rooms is of sufficient strength, and carried sufficiently high. It is desirable that there should be a door in it below the water line, but it is also desirable that this door should be placed as high in the bulkhead as is consistent with the purposes for which it is required, as was the case in this instance.

9. Having regard to the fact that this vessel had two engines entirely independent of each other, was the sail power sufficient?

We consider that the sail power was sufficient.

10. What was the cause of the cracks which developed in the columns, and were they efficiently repaired?

The cracks developed in the cast-steel columns of the engines were, in our opinion, caused by the contraction in cooling, which is greater in steel castings than in many other metals, and which, in consequence of the necessary structural arrangements of these castings, sets up considerable tension in some parts. The cracks in five of the columns of the engines were repaired by steel plates secured in a very efficient and workmanlike manner.

11. What was the cause of the lignum-vitæ in the bush in the starboard bracket wearing down about five-sixteenths of an inch, and was it properly and sufficiently re-lined and made good in January last?

We have no evidence that would enable us to express an opinion as to the cause of the lignum-vitæ in the bush of the starboard bracket wearing down about five-sixteenths of an inch, as it appeared when examined in dock in January last; we have evidence as to the manner in which it was re-lined, and we have no reason to suppose that it was not properly effected; but, looking to the fact that the lignum-vitæ in the bush of the port bracket had shown an inappreciable amount of wear at that time, it would have been more satisfactory to have withdrawn the tail shaft, so as to have re-lined the bush either in its place or in the workshop. The condition of the gun-metal casing or liner on the tail shaft would then have been exposed to a thorough inspection, and if a defect existed it would in all probability have been discovered.

12. Having regard to the wearing down of the lignum-vitæ in the bush, was it sufficiently examined thereafter?

Having regard to the statement that this ship was to be docked within two months in accordance with the requirements of the Board of Trade, we are of opinion that the opportunity that would have thus been afforded for further examination would have been sufficient.

13. Was it possible, either by observation or sound, to have discovered when the engines were working that the after bearing of the propeller shaft was worn down?

It was not possible to discover by observation, when the engines were running at sea, that the after bearing of the propeller shaft had worn down; but we would observe that when a propeller becomes loose on its shaft, or the propeller shaft becomes loose in its bearings, it generally gives unmistakable notice of its condition (by sound) to those who may happen to be in any near proximity to that portion of the ship to which it is attached.

14. What was the cause of the casualty?

We are of opinion that the primary cause of the casualty was the extraordinary wearing down of the bearing of the bracket which supported the extreme end of the propeller shaft, by which that end had dropped from its original and proper position about 7 inches; that this bearing down of the after end, its distance (about 50 feet) from its nearest support in the stern tube, coupled with the weight of the propeller and of the shaft itself, produced a bending effect on the shaft at its forward support, coexistent with each revolution of the engine; that this had probably produced rupture of the external surface which gradually extended inwardly, and finally to total fracture of the shaft; that the engine, being thus relieved from all resistance beyond the friction of its own moving parts, would almost instantaneously have acquired a greatly accelerated velocity, the result of which was probably sufficient, by the additional strains on the various connections, to diminish the clearance allowed between the piston and cylinder cover of the low-pressure engine at the top end of its stroke; that the cover was struck by the piston and moved off, the piston probably broken up in the act, the cylinder torn asunder, the condenser seriously broken, and the destruction of the various other parts rapidly accomplished. As to the cause of the wearing down of the after bearing of the propeller shaft, considerable difference of opinion appeared to exist. This wearing was of an abnormal character and of infrequent occurrence; generally it may be said to have been attributed to two distinct causes, one being that the gun-metal casing or liner of the shaft had burst through, being in a state of excessive tension. The other cause suggested was that ashes, which had been more frequently thrown overboard on the starboard side than on the port, had got into the bearing and set up the action that led to this wear, but there is scarcely a steamship running whose outer shaft bearings are not subject to the conditions that may be supposed to arise through ashes or other *debris* from the ship. What seems to have occurred is that from some cause or other the waterways in the lignum-vitæ strips became choked or were insufficient for the passage of water; that the friction which generated soon destroyed the lignum-vitæ; that the metal casing of the shaft and the bush being brought in contact, heat was further developed sufficient to break up the metal casing of the shaft—the fragments of which found in the outer protecting case of the shaft presented the appearance of metal that had been broken while hot—and that the high temperature of the rubbing surfaces of the shaft and its bearing caused the extraordinary wear that followed.

15. What was the cause of the water finding its way into the engine-room and other compartments?

The cause of the water finding its way into the engine-rooms and other compartments was that in the break-up of the engine a large portion of the low-pressure cylinder fell or was driven against the condenser, tearing away a considerable portion of its body, tube-plates, and tubes, and thereby opening a large communication with the sea; through this opening the water rushed in in such volume that before any of the inlets to circulating pumps could be closed they became covered by the water and out of reach. Water also passed in through the sea connections of the auxiliary condenser, and as previously described the water passed into the port engine-room through the dynamo-room, bulkhead doors, the injured bulkhead of this compartment, and through the apertures broken through the middle line bulkhead by the ruptured machinery, and at No. 10 by the injury to the forward bulkhead of that compartment, into Nos. 11 and 12 by serious injury to the valve box of the pumps in the engine-room, which were in connection with these compartments.

16. Was the bulkhead forward of the engine-room weakened by cutting away the lower portions of two of the stiffeners; did it leak or bulge after the casualty; and was the shoring necessary in order to insure its safety?

We do not consider that the cutting away of a lower portion of a stiffener on each side of the forward bulkhead of the engine-room materially weakened it, as the apertures cut were made good by substantial plate doors bolted thereto. The bulkhead, it was stated, did not leak; some slight bulging was said to have shown, but we do not consider that shoring would have been necessary to insure its safety.

17. Would it be desirable in future that the large sea connections should be capable of being closed from the main or upper deck?

We certainly consider it desirable that suitable means should be provided by which the main sea connections, such as inlets and discharges for the circulating water of the condensers, and the main steam stop-valves of the engines, could be closed from some convenient position on the main deck exterior to the engine-rooms.

18. Have the Court any suggestions or observations to offer which in their opinion might tend to obviate casualties of a similar nature in the future?

It will be readily understood that after the practically unanimous testimony of eminent authorities of the Board of Trade and of Lloyd's surveyors and various experts who have been called during this inquiry as to the strength, completeness, and efficiency in all respects of this ship for the service for which she was specially designed and constructed, the Court does not consider itself in a position to offer many suggestions or observations thereon. We may observe that during the course of this inquiry, we had evidence that even if some of the forward compartments of this ship had been filled with water in addition to those already filled aft, she would still have had a fair amount of freeboard, and have been able to float under the circumstances, her mean draught of water on arrival at Queenstown being only 8 inches or 9 inches more than when she left New York. We are of opinion, having regard to the trying ordeal through which she passed, that she has proved herself to be one of the finest and safest vessels in the mercantile marine. The Court would suggest that it is very desirable that a really efficient and trustworthy governor of the most approved form should be fitted to each engine and driven by the main shaft. It should be connected by suitable means to the main steam valve, and such other valves as may be directly affected in controlling the speed of the engines, and it should never be disconnected from the engines or thrown out of action while they were running. Such a fitting would obviate, if not entirely prevent, a serious casualty in case of shaft fracture or engines racing from any other cause.

The Court has been informed that only the bulkheads of the extreme forward and extreme after compartments of this ship had been tested with water pressure, and that this is the usual practice. The Court would, however, suggest the desirability of all so-called water-tight bulkheads being tested with water up to a certain height (say orlop deck), not by filling the compartments with water as appeared to be in the minds of some of the witnesses, nor even to test the strength of the bulkheads, but to test their water-tightness, and we are of opinion that this could be effected without much inconvenience or additional expense by the use of a hose-jet, and by running water up to the height mentioned. With reference to the supports for the outboard lengths of propeller shafting in large and fast ships generally, it is not intended to make any observations of an adverse character on that provided in the *City of Paris*, which was no doubt sufficient so long as the after bearing continued in a normal condition; but in view of the considerably increased length of these shafts in recently constructed fast ships, and the possibility, happily very unusual, of a similar wearing down of the end of the bearing, and from which there is no immunity, fracture of the shaft, with corresponding destruction of the engine and its consequences, would in all probability take place. The Court would, therefore, suggest that this is a question of sufficient importance to deserve the careful consideration of naval architects and engineers. The Court would suggest the desirability of isolating each water-tight compartment from others as far as possible; but having regard to the convenience and advantage of steam pumping power as compared with manual, the Court is of opinion that where it is applied to the various compartments in the ship by connections with pumps in the engine-rooms, suitable means should be provided for closing and opening these connections from the main deck. Before closing our remarks on this case, the Court desires to refer to the admirable manner in which the captain and deck officers, the chief engineer and his assistants, and the crew generally, performed their duties, and conducted themselves in the trying position they were placed in after this casualty. The Court is of opinion that this was in a great measure the cause of the calmness and confidence exhibited by the passengers, and of their general praiseworthy conduct under circumstances not devoid of peril. And further the Court wishes to say that during this inquiry they have received every assistance from all parties concerned to arrive at the conclusions embodied in this report.

REPAIRS TO MACHINERY OF THE S. S. CITY OF PARIS.

In this connection, the following extracts from *Engineering*, May 8, 1891, concerning the new machinery, recently completed and tried, are of interest:

The Inman liner *City of Paris* has had a new engine fitted on board in lieu of that which unfortunately broke down on the Atlantic a year ago as a consequence of the breaking of the shaft, and at the end of last week she went on speed trials with results which promise much for the future. * * * The new main engines are of exactly the same design as those originally fitted into the vessel. Indeed, many of the parts, which, on being tested, were found to be thoroughly good, have again been used. Of the high-pressure engine there were found suitable for use the piston, piston-rod, connecting-rod, eccentrics, eccentric-rods, valve motion, air pump lever and air pump complete, soleplate, and one of the supporting columns; and of the intermediate engine the piston-rod, connecting-rod, eccentrics and valve motion, with one column. The low-pressure engine (which first gave way) is entirely new, but as we have already indicated, is of the same design, the old patterns having been utilised. The shafting is new from end to end. It is of the same diameter as formerly, the crank being 20¼ inches with a hole 3¼ inches diameter through the pins, which are 21 inches. The crank-shaft is made in three interchangeable pieces, which are 11 feet 6 inches long. The thrust shaft is 16 feet 9 inches long with a diameter of 19¼ inches and 20¼ inches between the collars. There are three tunnel shafts 22 feet 9 inches long and 19¼ inches in diameter. The tube shaft is 44 feet 6 inches long. All the shafts are made of Vickers steel.

The shaft bearing in the after bracket has been lengthened by 9 inches, making it 7 feet in length, notwithstanding that the Court considered that formerly it was sufficient. A change has been made in the method of packing the lignum-vitæ. There is a strip of brass between each of the lignum-vitæ strips, and the wood is placed with the grain end-on against the shaft. This is instead of the system formerly employed, that adopted in the Admiralty, of putting in lignum-vitæ staves. Indeed, the method of packing now employed is a recurrence to former practice, Penn's original design being adopted. As an evidence that it must have been extraordinary circumstances which caused the collapse of the bearing of the starboard engine in the *City of Paris* last year, it is worth noting that, on the *City of New York* being docked the other day and her bearings examined, it was found that neither the port nor starboard bearing had worn to any appreciable extent after eleven voyages. Besides, the bearing of the port shaft of the *City of Paris* showed no wear, and these three bearings were of the same construction as that which so completely failed after only one voyage.

To enable the exact level of the tube shaft to be ascertained, the idea of the sounding lead has been borrowed. Through the counter of the ship, at a point immediately in line with the tube carrying the shaft, a hole has been bored and lined with a brass tube. Through this tube there is passed an iron tube, made up of suitable lengths screwed together as they pass through the hole, and these are dropped into a cup in the A-frame or propeller bracket. This cup allows direct communication with the shaft, and the rod is thus brought into contact with the top of the shaft. The length of the brass rod, which is rigid, indicates on a gauge whether the shaft has dropped even to the extent of the sixty-fourth part of an inch. Thus it is possible to ascertain if there is any wearing of a shaft while the vessel is at sea or in harbour. This arrangement, it may be added, is now at work on the *City of New York*, the simple appliance having been introduced at the opening of last season.

There has been fitted to the main engines a device which controls the engines and stops them whem they exceed a fixed number of revolutions. * * * In the Irish Sea on Saturday last this controlling gear was put in operation, being arranged to stop the engines at 80 revolutions, and on the speed being intentionally accelerated the gear did its work quickly and effectively.

The changes in the boiler arrangements necessitated by the substitution of Howden's closed ash-pit system of forced draft for the closed fire-room system formerly used, are described in the notes on Forced Draft.

SHAFT-BEARINGS.

THE ACCIDENT TO H. M. S. ANSON.

Serious defects were discovered in the shafting of the first-class battle-ship *Anson* when that vessel was docked at Devonport, after the summer manœuvres of 1890. The following extract relating to the matter is from the London *Times*, September 5, 1890:

> Yesterday the men of the chief engineer's department went into the dock for the purpose of examining the *Anson's* under-water fittings, and discovered a defect similar in its nature to that which, it is supposed, caused the disaster to the well-known liner *City of Paris*. Upon examining the propeller and stern fittings on the starboard side it was found that the ship's shafts were defective as regards both coupling bolts and the frame bearings. Two of the coupling bolts were broken, while the others were considerably worn, and the shafting was not in line on the port side. The coupling bolts also were much worn. These defects could not possibly have been discovered by the engine-room staff of the ship, and had they not been fortunately found out, and had the *Anson* proceeded to sea, there would have been serious risk of the shafting giving way and of much damage being done to the ship.

According to the *Naval and Military Record*, October 2, 1890, these defects were ascribed "to the bracket bearings having been improperly bored out in the first instance, thus bringing an undue strain upon the shafts."

BASIN TRIALS OF H. M. S. KARRAKATTA AND H. M. S. KATOOMBA.

Comment has already been made on the difficulty which is being experienced in supplying shaft bearings of sufficient durability to the gunboats of the *Sharpshooter* class. At Newcastle-on-Tyne, where the *Karrakatta* and *Katoomba* are building by contract, similar difficulties have made themselves felt, and it is stated that after undergoing eight basin trials the thrust and bracket bearings of the latter vessel have worn down to the extent of $\frac{3}{16}$ inch. It is estimated that the *Katoomba* would have covered about 1,000 miles during these trials, and the critics are asking how it will fare with these ships when they are required to make the voyage to Australia. The old lignum-vitæ bearings have been discarded, as it was found that this material could not resist the friction caused by the great number of revolutions of the shafts, but a similar difficulty has been hitherto experienced with the metal bearings that have been substituted for the lignum-vitæ.

Naval and Military Record, January 15, 1891.

DEVICES FOR DETECTING WEAR OF SHAFT-BEARINGS.

The device adopted in the *City of Paris* since the accident to that vessel, and fitted also in the *City of New York*, has been already described in connection with the new machinery of the *City of Paris*. An electrical device for the same general purpose has been patented by Mr. George Hannah, of Brooklyn, N. Y., which would appear to merit careful consideration. In explanation of this invention, the following may be quoted from the specification (forming part of Letters Patent No. 449,411, dated March 31, 1891):

> The invention may be carried out by running insulated electric wires, positive a negative, from the engine-room, at which place these wires would be connected wit battery and indicator, and through and under the journals at the stuffing-box, an then along the tube which incases the shaft from the point where it goes outboar at the stuffing-box to where it rests on the bracket. At this point the insulated wire should turn from the horizontal to the perpendicular and terminate with their en incased in the bracket-bearing, say about an inch or somewhat less, under its surfac The incasing tube should have a groove made along its whole length, so that the

insulated wires will rest in the bottom of same and out of reach of the shaft revolving therein. In the event of the bracket-bearing wearing down that half-inch, or whatever distance the "terminals" were set at, the shaft revolving would come in contact with the wires, the insulation be speedily worn off, contact made, the circuit closed, and the engineer immediately notified by the alarm bell connected with the battery in the engine-room.

JOY'S "ASSISTANT CYLINDER" FOR MARINE ENGINES; LATEST TYPE.

The accompanying illustration (Pl. I.) is from Mr. David Joy's paper read before the Institution of Naval Architects, March 20, 1891, and represents in section, in connection with a slide-valve, the latest and most improved form of "assistant cylinder" of his invention, the result of experiments in this field extending from the spring of 1889 to the present year. The design illustrated is for the double-ported valve of a low-pressure cylinder of 56 inches diameter, with a valve travel of 6 inches.

The purpose of the invention is not to supplant, but to assist the eccentrics or other valve gear, by relieving them of the greater portion of the work of operating large valves, and so avoiding the great strains commonly thrown upon the various parts of the valve mechanism. Mr. Joy's paper, which may be found in full in *Engineering*, April 10, 1891, describes and illustrates, in addition to the form copied here, the various forms of the invention which have been tried at different times during the past three years, and shows how the present form was arrived at. The efficiency of each arrangement was studied from indicator cards taken from the "assistant cylinder", and alterations of design were adopted accordingly as these cards showed the direction improvement should take. In addition, all changes were towards greater simplicity.

In the earliest form of the invention, as applied in the British torpedo-gunboat *Skipjack*, in 1889, a separate valve was used to effect the distribution of the steam in the "assistant cylinder"; this was soon changed, however, so that the piston became its own valve, and in this form the appliance was fitted in the Chilian torpedo-gunboat *Almirante Lynch*. Slight modifications were later made in the design as applied in two other torpedo-gunboats, the *Rosales* and *Espora*, built by Messrs. Laird for the Argentine Government, and other small changes have led to the adoption of the present arrangement. In its final form, the piston is in entire balance, receiving steam all round and exhausting all round; the ports are ample in area and have ample cover; the cylinder with all the ports is the result of one boring; and the piston is the result of one turning.

The following is the conclusion of Mr. Joy's paper:

> The machine is made to take the place of the ordinary balance cylinder. But it does much more, as has been seen; it should take most of the strain of moving the valve away from the ordinary valve gear, so saving wear and tear and the trouble often given by eccentrics. And doing this it is equally applicable to horizontal en-

gines. The engine is simplicity itself, consisting only of a cylinder and a piston, the latter locked on to the end of the valve spindle; so there are no loose parts to shake away, no special arrangements to make which may alter or vary by looseness. But the piston itself performs all the functions of distributing the steam and releasing the exhaust—but that being so the remark may be made, then you can get no more steam than you have "lead"; of course that is so. But, firstly, we want a good deal of lead for efficient "cushioning"; and, to provide steam for each driving stroke, sufficient clearances are allowed at each end of the cylinder and in the piston, to allow of what, to use a gunnery term, I may call a "charge" of steam, sufficient by its expansion to give out all power required, as shown in the diagrams * * *.

Then for the manipulation of the machine; on starting the main engines, it is only necessary to turn on a "whiff" of steam, to slightly fill the cylinder (so that it becomes inoperative but not obstructive), till the main engines have fairly moved; more steam is admitted as the speed increases, till by the quiet of the valve motion it is clear that the assistant cylinder has settled to work.

The system has now been taken up * * * both in this country and on the Continent, and promises * * general adoption on the class of engines for which it was designed.

BOILERS.

COLD WATER ON RED-HOT FURNACE CROWNS; EXPERIMENTS BY THE MANCHESTER STEAM-USERS' ASSOCIATION.

The report by Mr. Lavington E. Fletcher to the members of the executive committee of the Manchester Steam-Users' Association upon the interesting and important experiments conducted for that association under his supervision, to ascertain the effect of showering cold water on red-hot furnace crowns, has been published in full in *Engineering*, in its issues of January 30, 1890, February 13, March 6, March 13, and April 17, 1891. These experiments were undertaken with the view of throwing light upon the truth or fallacy of the widely-accepted theory that the effect of the injection of cold feed-water into a boiler in which the furnace crowns have become red-hot would be the instantaneous generation of a volume of steam so great that the safety valves would be inadequate to release it quickly enough to prevent explosion.

As long ago as 1867, the Manchester Steam-Users' Association made some experiments in this field by injecting water into red-hot household boilers and found that no explosion resulted. It was believed that similar results would attend a trial with a steam boiler of larger size, since theory would indicate, from consideration of the low specific heat of iron, that no very great amount of steam could be generated by the heat stored in furnace crowns even when red-hot; but in deference to the wide prevalence of views to the contrary, it was determined by the Association to submit the vexed question to a practical test. The conduct of the experiments was intrusted to Mr. Fletcher, and the Association has now published his report for the public benefit.

The boiler used was of the ordinary Lancashire internally-fired, two-flue type, the flues lap-jointed and single-riveted, not strengthened by rings or flanged joints. It was thought that this would afford a fairer test than a boiler of more recent fashion, having flues with welded

ASSISTANT CYLINDER FOR MARINE ENGINES.

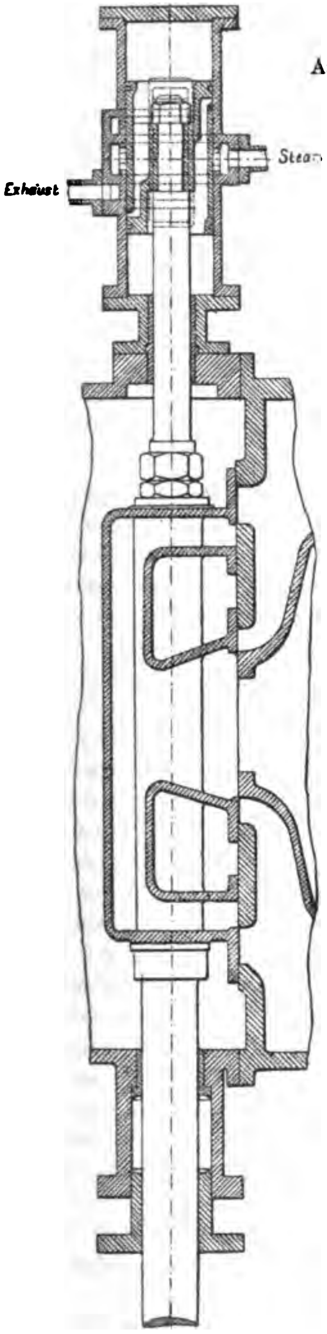
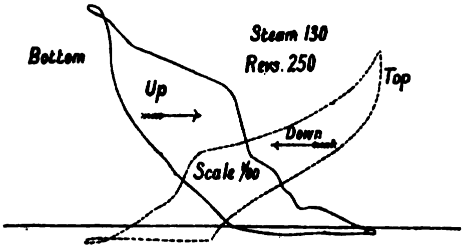


Diagram from Assistant Cylinder, Piston its own Valve, with final Adjustments, on Torpedo Gun-boat Almirante Lynch, Sept. 15th, 1890.



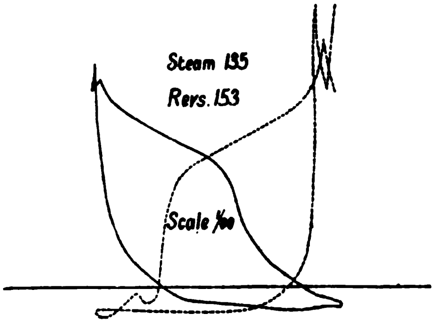


Diagram from Assistant Cylinder on Rosales, Oct. 27th, 1890.

longitudinal joints, and strengthened circumferentially by flanged seams or otherwise. The length of the boiler was 27 feet, 9 inches; diameter, 7 feet; diameter of flues, 3 feet; thickness of shells, $\frac{7}{16}$ inch; heads, $\frac{9}{16}$ inch; flues, $\frac{7}{16}$ inch. The material was iron throughout. The ends, back and front, were strengthened by four gussets above the flues, and by two gussets below at the front, and one at the back. The grates measured 3 feet in width by 6 feet in depth. The boiler was set in the usual way on two longitudinal side-walls, the gases passing back through the flues, then forward under the boiler, and back along the sides to the chimney. The latter was 72 feet in height, with a minimum cross-area of 14 square feet. The cross-area of the flue leading from the boiler to the chimney was 7.57 square feet. It may be seen that these dimensions were ample. A U-tube was connected to the chimney, 4 feet 6 inches from the ground, to show the intensity of the draft.

The boiler was fitted with two feed valves, 2½ inches in diameter, at the front end, one on each side, with the center of inlet in each case at a height of 6 inches above the furnace crowns. The feed pipes inside the boiler were so arranged that the feed could be delivered, in different experiments, either back of the fire grates as in ordinary practice, or showered in jets upon the furnace crowns directly over the fire. Two water-gauges were arranged, at different heights, so as to show the water level over a range of from 16 inches above the furnace crowns to 16 inches below, the latter being within 2 inches of the level of the grate-bars. One blow valve of 2½ inches diameter was fitted, and two safety valves of 3 inches and 4 inches diameter respectively. Pressure was indicated by a 7-inch dial pressure-gauge, reading to 150 pounds, fitted with a maximum tell-tale finger. Three gauge-rods were attached to the crown of each flue, at distances, respectively, of 4 feet, 6 feet 9 inches, and 12 feet from the front end, and were carried up through stuffing-boxes in the boiler shell. These were for the purpose of observing vertical movement of the flues. Two test taps were fitted to the front end of the boiler to ascertain the temperature of the water at different levels. Observations were made from a wooden hut or observatory, at a distance of 33 feet from the boiler, properly protected, and with suitable arrangements within for operating all the valves and making the observations with safety.

To render the conditions of the experiments similar to those that would arise in practice, supposing one boiler in a battery of three or four to become short of water, and to have the feed supply of the entire battery turned upon it, a feed pump was used of such capacity as to be able to deliver in a given time a weight of water three or four times the weight of steam that could be generated by the boiler in the same time. In connection with this pump, a measuring tank was fitted, in order to ascertain the amount of water showered upon the crowns when red-hot.

Preliminary observations.—Preliminary observations not without interest were made in getting up steam for the first experiment. Temperatures were noted at intervals at the water level and at the bottom of the boiler, and exhibited such striking differences, indicating circulation so defective, that this question was afterwards made the subject of an independent series of experiments conducted by Mr. Fletcher upon a number of mill boilers of the Lancashire and Galloway types, the results of which are given in a supplementary appendix to his report. The observations made in the later experiments did not differ widely from those recorded in the experiments now under consideration, some of which may be cited in illustration. When fires were started, with water 10 inches over the furnace crowns, the temperature of the water at the surface was 83° F., and at the bottom, 78° F. Forty-five minutes later, there was a pressure of 7 pounds of steam, whilst the temperature of the water at the bottom had risen only to 89° F. Twenty-three minutes later, the steam pressure was 50 pounds, and the temperature at the bottom only 103° F. The intensity of the chimney draft during this time was $\frac{7}{16}$ inch of water, and the temperature of the chimney gases, 410° F. Some hogging of the flues was observed in getting up steam, amounting at the maximum, by the gauge-rod 12 feet from the front end of the boiler, to $\frac{19}{32}$ inch for one flue, and $\frac{17}{32}$ inch for the other.

Experiment 1.—At the beginning of this experiment, the water stood at a height of 8¼ inches above the furnace crowns. The safety valves were propped open. The blow valve was opened and kept open for 19 minutes, until the water was brought down to the level of the furnace crowns. The fires were then worked up into good condition, after which the blow valve was again opened and kept open until the water level had fallen to 16 inches below the furnace crowns. This required 20 minutes. To insure overheating of the bare crowns the water was allowed to stand for 5 minutes longer, at the end of which time, the 4-inch safety valve being left open, the 3-inch valve was closed, and at the same instant the feed water, at a temperature of 62° F., was showered on both furnace crowns, immediately over the fires, at the rate of 5½ cubic feet per minute. The steam pressure rose from 6 pounds to 12 pounds in 1¼ minutes. The injection of the feed was kept on continuously, and in 1¾ minutes the pressure fell to 1 pound.

Experiment 1*a*.—This was a repetition of the first experiment, with the difference that both safety valves were closed at the instant the feed was turned on, the water level having been reduced as before to 16 inches below the furnace crowns. The fires were about 7 inches thick, full and bright, the dampers open wide. The steam pressu rose in ¾ minute from 6 pounds to 27 pounds, after which it gradual fell, the feed being kept on continuously. In 13½ minutes the pres ure was reduced to 6 pounds, and in 20 minutes the water was brough up to the level of the furnace crowns and the pressure had fallen to pounds.

The boiler was so thoroughly heated at this test, that two blisters, one about 20 inches by 9 inches and the other about 10 inches by 6 inches, were developed on the crown of the left-hand flue. Diagrams of the movements of the furnaces, as measured by the gauge-rods, showed hogging, as had been observed in getting up steam, but more pronounced, amounting at the maximum to a little more than 1⅜ inches at the gauge-rod 12 inches from the front end of the boiler.

On examining the furnaces after this test, the plates were found to be severely sprung at each of the circumferential seams of rivets over the fires. The greatest distortion was found by gauging at the third circumferential seam of the right-hand flue, 7 feet 6 inches from the front end, the horizontal diameter at this point measuring 3 feet 1¼ inches and the vertical diameter 2 feet 9¾ inches. This was the full extent of injury to the boiler.

Experiment 2.—In preparation for this experiment the crown plates injured in the previous test were taken out, re-rolled, and riveted again in place. The boiler was then tested by hydraulic pressure to 100 pounds, and proved tight, whilst the flues on being gauged showed no movement.

It was determined to repeat as nearly as possible in this experiment the conditions of the one preceding, with the difference that it was to be made under a considerable pressure. A special device was adopted for the purpose of affording information as to the condition of the furnace crowns. It was desired that the feed should be turned on at the moment when the crowns should be red-hot and upon the verge of collapse, yet before collapse should have actually begun. With this object in view, to secure warning of the overheating of the furnace crowns, one of the three gauge-rods fitted to each flue for the observation of its vertical movements was secured to the flue by means of a fusible disc. Upon the melting of this disc, a counterbalance weight connected to the gauge-rod would become released, and by its fall would give warning that the time to turn on the feed had arrived. In addition to this, observers carefully watched the indications of the other gauge-rods as shown by indicators in the observatory.

The safety valves were set at 40 pounds pressure, and were upon the point of blowing off at the beginning of the experiment, when the water was 6 inches above the level of the crowns, brisk fires burning, and dampers wide open. The blow valve was opened wide, and in 8 minutes the water level was brought down to 15 inches below the furnace crowns. The blow valve was then closed. Relying upon the fusible discs to give warning of overheating, the observers noted the indications of the gauge-rods, which showed a progressive hogging of the flues as in the previous experiments, until 10 minutes after the reduction of the water level to the height of the furnace crowns, and 6 minutes after its reduction to 15 inches below the crowns, when a retrograde movement was observed on the part of the right-hand flue, indicating that it was beginning to come down.

The order was immediately given to turn on the feed, but the valve had scarcely been opened when the flue collapsed; a large rent was torn at the first circumferential seam, through which the steam and water rushed with great violence. The upper portion of the bridge wall was carried back through the flue and forward again through the external flue until it reached the cross-wall at the front, but the fire doors were not blown open, nor was the boiler disturbed upon its setting. The shell was uninjured, and the damage to the boiler was virtually confined to the one collapsed flue. The other flue was not visibly distorted, but gauging showed two belts of plating to be bulged down about 1 inch at the crown. The rent in the collapsed flue measured 3 feet on the circumference, with a maximum width of 1 foot at the middle. It was thought by the observers at the time, that collapse had begun before the feed valve was opened, and the subsequent experiments would appear to confirm this view.

Examination of the interior of the boiler disclosed the fact that the fusible discs had melted and fallen to the bottom in the form of shot, but this had not been indicated by the gauge-rods to which they had been attached, on account of these rods having stuck in their stuffing-boxes, the counterbalance weights not having been sufficient to overcome the friction of the packing. This experiment was, therefore, a failure, and the only lesson to be learned from it would appear to be, according to Mr. Fletcher's report, that, in some instances at least, a furnace crown when overheated may collapse without warning, and that, when shortness of water occurs in a boiler, to stand before a furnace to haul the fires, relying upon the gradual movement of the crown to give warning of collapse, is a very hazardous undertaking.

Experiments 3, 3*a*, 4, 4*a*, 5, 5*a*, 5*b*, 5*c*, 6, *and* 7.—After the damages occasioned by the failure of the experiment just described had been repaired, and fusible gauges of an improved form had been fitted to the top of the flues, a series of progressive tests were undertaken upon somewhat different lines. It was determined to lay bare the furnace crowns by evaporation instead of by blowing off (thus copying as closely as possible the conditions under which shortness of water would occur in a boiler in actual service), and to feel the way, step by step, to the proper moment for turning on the feed, in the following manner: the water would be brought down to the level of the furnace crowns, and the fires kept burning briskly for 5 minutes, and then the feed would be turned on; if no injury should result, the experiment would be repeated with an interval of 10 minutes instead of 5; and still no injury should result, the interval would be increased to 15 mi utes, and so on.

It is unnecessary to detail all the experiments of this series. T last and severest test was conducted in the following manner: t safety valve having been set at 25 pounds, the steam pressure wa raised until both valves were blowing, the water standing 9½ inch above the furnace crowns. The blow valve was then opened and the water blown down to the level of the crowns, after which the blow valve was closed. To secure the intensity of the fires for as long a period as possible, the furnaces were charged after this, although the water was already beginning to leave the crowns; the observers then withdrew from the front of the boiler, leaving fires 9 inches thick, burning briskly, the dampers wide open, the draft-gauge showing about ½ inch of water, steam pressure 29½ pounds, and both safety valves blowing fiercely. After 23½ minutes from the time at which the water had been reduced to the level of the furnace crowns, the fusible gauge attached to the right-hand flue indicated that the crown of this flue was red-hot. The feed was immediately turned on, showering water at a temperature of 60° F. directly upon the furnace crown at the rate of about 4½ cubic feet per minute; the water level at the time was 3⅝ inches below the crown, so that a strip of plating 21 inches wide was laid bare; the steam pressure was 28½ pounds, the safety valves blowing freely.

Upon turning on the feed, the steam pressure at once began to fall, and in 2½ minutes it had fallen to 26 pounds. Meanwhile, 2 minutes after the feed had been turned on the right-hand furnace crown, the fusible gauge attached to the other crown indicated that a red heat had been reached. On looking into the furnaces it could be seen at this time that the circumferential seams over the fire were leaking freely. The crowns of both flues were discolored on the fire side, the discoloration in each case being about 1 foot in width and 8 or 9 feet long. The line of demarcation between the portion of the flue which had been overheated and that which had not was quite marked, the sides being coated with soot whilst the crowns were brick-red in color and quite bare. Examination of the boiler on the following day showed that the overlaps of the first seven circumferential seams in each furnace were sprung at the crown, but the flues were virtually unaltered in shape; though the right-hand flue was slightly bulged in three places, the largest of these bulges being about 10 inches by 11 inches, and $\frac{5}{32}$ inch deep in the middle.

Summary.—In summary and conclusion, the following extract from Mr. Fletcher's report may be quoted:

> The question arises whether the experiments show that in the event of shortness of water it would be well to turn on the feed in every case.
>
> The fact that when the feed was showered on to the red-hot furnace crowns with the safety valves blowing, as in experiment No. 7, there was no rise of pressure, but, on the contrary, a fall, would seem to show that if the engine were running, so that any small amount of steam that might be generated by the injection of the feed would be carried off, the feed could be turned on with advantage, as it would tend to lower the pressure, restore the water level, and at the same time cool and reinvigorate the furnace plates. This would afford the attendant more time for drawing the fires, and thus act in his protection.
>
> On the other hand, however, the fact that when the feed was showered on to the

furnace crowns with one safety valve seated and the other open, as in experiment No. 1, the pressure rose in 1¼ minutes from 6 pounds to 12 pounds, and when the feed was showered on to the furnace crowns with the safety valves seated, as in experiment No. 1A, and thus with the steam bottled up, the pressure rose in three-fourths of a minute from 6 pounds to 27 pounds, suggests the question whether if the engine were standing and the furnace crowns red-hot, the injection of the feed might not cause a rise of pressure of some 10 pounds or 20 pounds, and whether this rise of pressure might not be sufficient to turn the scale and cause the furnace crowns to collapse, though it might not lead to the rending or displacement of the shell.

In reply to this it may be pointed out that in the experimental boiler, when the pressure was raised from 6 pounds to 12 pounds in one case and from 6 pounds to 27 pounds in another, the feed was not injected through a single ordinary dispersion pipe at one side of the boiler, and behind the firebridge, as in general practice, but through two specially contrived experimental dispersion pipes which injected the feed directly upon both furnace crowns just over the fire. The cases, therefore, are by no means parallel, while if the precaution were taken to ease the safety valves so as to allow them to blow freely and slightly reduce the pressure before turning on the feed, and if the feed dispersion pipe were made long enough to extend well back behind the firebridge, an arrangement which is recommended for general adoption, the probability of any increase of pressure on the injection of the feed would be very remote.

At the same time, however, it is thought that the experiments hardly allow of a positive opinion being formed on this point, and that further experiments would be necessary before this could be done.

* * * * * * *

These experiments clearly put to the rout the generally entertained opinion that showering cold water on to red-hot furnace crowns would cause the "instantaneous disengagement of an immense volume of steam", which would act "like gunpowder", overpowering the safety valves, however efficient, tearing the outer shell of the boiler to pieces, and hurling the fragments to a considerable distance. Yet these opinions have been repeated again and again; the credence they have obtained has tended much to mystify the subject of steam boiler explosions, and by leading astray from the true cause, to perpetuate the recurrence of these disasters.

SERVE'S PATENT RIBBED BOILER-TUBES.

TRIALS AT ATLAS WORKS, SHEFFIELD, ENGLAND.

The Serve boiler-tube, differing from the ordinary boiler-tube in having on the inside a number of longitudinal ribs (eight, as manufactured) designed to increase the efficiency of the tube heating surface by exposing additional heat-transmitting surface to the products of combustion, has been taken up by the firm of John Brown & Co., Limited, Sheffield, proprietors of the Atlas Works. This boiler-tube has been in use to a limited extent since 1886, but was at first manufactured only in brass and copper. A series of comparative trials with brass tubes was made under the direction of the French naval authorities at Brest, France, in November and December, 1888, which showed an average gain in economy, measured in evaporation per pound of coal, in favor of the Serve brass tubes over plain brass tubes, of 14.75 per cent. with natural draft, and 19.9 per cent. with forced draft. The tubes are now manufactured in brass, copper, and steel, the mechanical difficulties which at first prevented the adoption of the latter metal having been overcome. A series of trials of steel tubes of this patent was carried out at the Atlas Works, October 21, 22, 23, and 24, 1890, a number of engineers, including representatives of Lloyd's, the British Admiralty, and various foreign governments, having been invited to be present and check the results.

The boilers used in the trials were two single-ended marine boilers of the common return tubular type, exactly alike with the exception of the tubes, boiler No. 1 being fitted with Serve tubes, and No. 2 with plain tubes. The following are the particulars of the boilers, from which it may be observed that the tube heating surface, as measured inside the tubes, shows a considerable excess for boiler No. 1:

	No. 1.	No. 2.
Diameter of boilers	10 feet 6 inches	10 feet 6 inches.
Length of boilers	do	do.
Inside diameter of furnaces (two in each boiler)	2 feet 10½ inches	2 feet 10½ inches.
Total number of tubes	126	126.
Outside diameter of all tubes	3¼ inches	3¼ inches.
Thickness of ordinary tubes	⅛ inch	⅛ inch.
Number of stay tubes	34	34.
Thickness of stay tubes	⅜ inch	¼ inch.
Length of furnaces and of all tubes, inside of boiler	7 feet 6½ inches	7 feet 6½ inches.
Heating surface of each ordinary tube	10.42 square feet	5.95 square feet.
Heating surface of each stay tube	do	5.45 square feet.
Total heating surface of tubes	1312.9 square feet	732.7 square feet.
Area of grate surface	31 square feet	31 square feet.
Heating surface of furnaces	135.5 square feet	135.5 square feet.
Heating surface of combustion chamber	88 square feet	88 square feet.
Total heating surface of boilers	1536.4 square feet	956.2 square feet.
Ratio of heating surface to grate surface	49.56 to 1	30.84 to 1.
Total tube area for passage of gases	802.36 square inches.	852.18 square inches
Width of firebars, square bars	1 inch	1 inch.
Distance between firebars	½ inch	½ inch.
Chimney, rectangular section	4 feet by 2 feet	4 feet by 2 feet.
Height of chimney from top of combustion chamber	43 feet 7 inches	43 feet 7 inches.

Throughout the trials the coal used was Nixon's Navigation. Induced draft, on the Martin system, was used in all the experiments except in the natural draft trial of the first day. No trouble was experienced at any time with either the boilers or the tubes. The following is a summary of the trials:

First day, October 21, 1890.—Three hours' trial with induced draft, with a vacuum in front-connection of 1½ inches of water.

		Boiler No. 1. Serve.	Boiler No. 2. Plain.
Total coal burned	pounds	3,808	4,144
Evaporation, ½ hour	gallons	345	310
Evaporation, 1 hour	do	935	870
Evaporation, 1½ hours	do	1,555	1,465
Evaporation, 2 hours	do	2,115	2,030
Evaporation, 2½ hours	do	2,615	2,510
Evaporation, 3 hours	do	3,250	3,100

Comparative results.

	Per cent.
Evaporation, excess in No. 1 over No. 2	4.8
Gain in economy in No. 1 over No. 2	14.1

Same day.—Three hours' trial with natural draft.

	Boiler No. 1. Serve.	Boiler No. 2. Plain.
Total coal burned.......pounds..	1,810	2,240
Evaporation, 1 hour.......gallons..	605	640
Evaporation, 1½ hours.......do....	920	980
Evaporation, 2 hours.......do....	1,210	1,300
Evaporation, 2½ hours.......do....	1,510	1,680
Evaporation, 3 hours.......do....	1,820	2,010

Comparative results.

	Per cent.
Evaporation, excess in No. 2 over No. 1	10.4
Gain in economy in No. 1 over No. 2	12.1

Second day, Oct. 22, 1890.—Twelve hours' trial with induced draft, so regulated as to make the coal consumption the same for both boilers.

BOILER NO. 1 (SERVE TUBES).

	Coal burned.	Water evaporated.	Vacuum at base of chimney.	Steam pressure.	Temperature of feed.
Hours.	*Pounds.*	*Pounds.*	*Inches.*	*Pounds.*	*Degrees.*
1	1,568	9,000	1¼	16⅛	59
2	2,800	19,300	1	12⅛	66
3	3,808	27,000	1¼	15	60
4	4,928	39,800	1¼	11	61
5	5,824	49,600	1	10	60
6	6,832	59,300	1¼	11	60
7	7,504	68,600	1¼	10	60
8	8,400	77,200	1¼	10	60
9	9,520	87,300	1¼	11¼	60
10	10,416	96,000	1¼	10⅛	60
11	11,200	105,800	1⅛	10¼	60
12	11,872	114,600	1	10	60

BOILER NO. 2 (PLAIN TUBES).

1	1,568	7,800	1⅛	9½	59
2	2,800	16,200	1⅛	8½	61
3	3,808	25,300	1½	9	61
4	4,928	34,400	1¼	6	60
5	5,824	43,000	1⅛	6	61
6	6,832	52,300	1⅛	10	60
7	7,504	61,500	1⅛	6½	61
8	8,400	69,300	1⅛	6¼	60
9	9,520	78,500	1¼	8	60
10	10,416	87,500	1	6¾	60
11	11,200	95,100	1⅛	4½	61
12	11,872	103,000	1⅛	6¼	60

Comparative results.

	No. 1.	No. 2.
Pounds of water evaporated per pound of coal, at actual temperatures	9.65	8.68
Pounds of water evaporated per pound of coal, from and at 212° F.	11.19	10.05

	Per cent.
Evaporation, excess in No. 1 over No. 2	11.26
Gain in economy in No. 1 over No. 2	11.34

Steam was blown off through the open safety valves into the air; but the valves, of which there were two to each boiler, with openings of 3½ inches diameter, were inadequate to keep the pressure from accumulating.

Third day, October 23, 1890.—Seven hours' trial with induced draft, with a vacuum at base of chimney of ¾ inch of water.

BOILER NO. 1 (SERVE TUBES).

	Coal burned.	Water evaporated.	Vacuum at base of chimney.	Steam pressure.	Temperature of feed.
Hours.	*Pounds.*	*Pounds.*	*Inches.*	*Pounds.*	*Degrees.*
1	6,496	7,500	¾	11	63
2		17,600	¾	12½	60
3		26,900	¾	9	64
4		35,400	¾	9	62
5		44,300	¾	8½	63
6		53,060	¾	9	63
7		61,500	¾	9	62

BOILER NO. 2 (PLAIN TUBES).

	Coal burned.	Water evaporated.	Vacuum at base of chimney.	Steam pressure.	Temperature of feed.
1	6,496	6,300	¾	8¾	64
2		15,300	¾	6¾	66
3		23,400	¾	4½	62
4		30,400	¾	4½	62
5		38,200	¾	4	63
6		45,800	¾	4½	63
7		53,200	¾	4½	62

Comparative results.

	No. 1.	No. 2.
Pounds of water evaporated per pound of coal, at actual temperatures	9.47	8.19
Pounds of water evaporated per pound of coal, from and at 212° F.	11.03	9.50

	Per cent.
Evaporation, excess in No. 1 over No. 2	15.6
Gain in economy in No. 1 over No. 2	16.1

In this trial, as in the one of the previous day, the safety valves were open, but were insufficient to keep down the steam pressure.

Fourth day, October 24, 1890.—Seven and one-fourth hours' trial with induced draft, with a vacuum at base of chimney of ⅝ inch for boiler No. 1, and of ½ inch for boiler No. 2.

BOILER NO. 1 (SERVE TUBES).

	Coal burned.	Water evaporated.	Vacuum at base of chimney.	Steam pressure.	Temperature of feed.
Hours.	*Pounds.*	*Pounds.*	*Inch.*	*Pounds.*	*Degrees.*
1	5,712	6,600	⅝	9	65
2		15,200	⅝	8¼	62
3		23,300	⅝	7	66
4		31,300	⅝	7½	64
5		39,100	⅝	7	64
6		45,300	⅝	6¼	63
7¼		56,100	⅝	6¼	63

BOILER NO. 2 (PLAIN TUBES).

1	5,404	6,000	½	4½	68
2		13,400	½	4¼	65
3		20,000	½	3¾	64
4		27,100	½	4	65
5		33,500	½	3	64
6		38,600	½	3¼	65
7¼		48,400	½	3	63

Comparative results.

	No. 1.	No. 2.
Pounds of water evaporated per pound of coal, at actual temperatures	9.82	8.96
Pounds of water evaporated per pound of coal, from and at 212° F.	11.39	10.36

	Per cent.
Evaporation, excess in No. 1 over No. 2	15.9
Gain in economy in No. 1 over No. 2	9.94

During this trial, as during those of the two days preceding, the safety valves were open to the full extent. The difference in the intensity of the draft in the two boilers was adopted with the view of equalizing in effect the cross-area through the tubes for the passage of the products of combustion.

Of these trials as a whole it may be said that, whilst the results are not as striking as in the case of the experiments conducted at Brest with the brass tubes, a sufficient gain in economy was shown to demonstrate the importance of the invention.

TRIALS OF THE SERVE TUBE AT ELIZABETHPORT, N. J.

The reported results of the comparative trials of Serve tubes and plain tubes conducted by Mr. H. B. Roelker, Member Am. Soc. Mech. Engrs., at the works of Samuel L. Moore & Sons, Elizabethport, N. J., in April, 1891, are more remarkable than those of either the Brest or the Sheffield trials. A brief summary of the experiments is given in *Engineering News*, May 9, 1891. Chiefly from this account the following particulars are derived:

The boiler used was an ordinary vertical tubular boiler of 3½ feet diameter, with a furnace 3 feet in diameter and 2 feet in height. The tubes, 63 in number, were of 2½ inches internal diameter and 6 feet in length. The total grate surface was 7 square feet, and the total heating surface was 287 square feet, of which 223 square feet, or 78 per cent., was in the tubes. Trials were first made with plain tubes during six days, April 6 to 11, inclusive, for eight hours each day, after which these tubes were taken out, the boiler was re-tubed with Serve tubes, and the trials were repeated as closely as possible, the second series extending from April 17 to April 21, inclusive, eight hours each day, as before. The water level was kept as nearly constant as possible throughout the trials, and the steam pressure was maintained at 70 pounds. The forced draft was obtained by means of a steam blast in the smoke-pipe. At the close of each six-day trial, the soot was scraped from the tubes and weighed; from the plain tubes 2¼ pounds were obtained, and from the Serve tubes 3 pounds.

Data of trials.

Kind of draft.	Intensity of draft, in inches of water.	Kind of tubes.	Date, April, 1891.	Average temperature of chimney gases.	Average temperature of feed.	Pounds of water evaporated in 16 hours.	Pounds of coal used in 16 hours.	Pounds of coal per square foot of grate per hour.	Pounds of water evaporated per pound of coal.
				Deg.	*Deg.*				
Natural	$\frac{1}{8}$	Plain	6 and 7	682	190	8, 705	1, 716	15. 32	5. 07
Natural	$\frac{1}{8}$, less $\frac{1}{124}$	Serve	15 and 16	443	196	10, 275	1, 401	12. 51	7. 33
Forced	$\frac{1}{2}$	Plain	8 and 9	828	186	16, 705	2, 788	24. 89	5. 99
Forced	$\frac{1}{2}$	Serve	17 and 18	453	189	21, 880	2, 881	25. 72	7. 59
Forced	$\frac{7}{8}$, less $\frac{1}{64}$	Plain	10 and 11	905	187	16, 650	3, 557	31. 76	4. 68
Forced	$\frac{7}{8}$	Serve	20 and 21	510	180	24, 380	3, 609	32. 22	6. 75

It may be derived from these observations that the gain in economy measured in pounds of water evaporated per pound of coal, obtained by the use of the Serve tubes, was 44.57 per cent. with natural draft, 26.71 per cent. with ½ inch forced draft, and 44.23 per cent. with ⅞ inch forced draft, whilst the evaporative capacity of the boiler was increased by the use of the Serve tubes 18.04 per cent. with natural draft, 39.78 per cent. with ½ inch forced draft, and 46.43 per cent. with ⅞ inch forced draft. It may be observed that the total evaporation for 16 hours with plain tubes was less with a draft of ⅞ inch than with that of ½ inch. It was inferred from this that the maximum evaporative capacity of the boiler, with plain tubes, had been attained in the trials. This was shown by the records to be at the rate of 8,460 pounds of water in 8 hours, with a draft of $\frac{27}{32}$ inch of water. For comparison with this, an additional trial with the Serve tubes was made on April 25, with a draft of $1\frac{9}{16}$ inches of water, the steam pressure standing at 100 pounds, and the water level 4 inches lower than in the previous trials. The result of this test showed a maximum evaporative capacity for 8 hours of 14,000 pounds of water, a comparison of which with the 8,460 pounds recorded in the case of the plain tubes, indicates an increase of 65½ per cent.

It appears from these trials that the efficiency of vertical tube surface is increased by the adoption of the Serve tube in a more marked degree than is horizontal tube surface. Such a result it would be natural to expect, although the striking differences shown in the tests would scarcely be anticipated.

EXPERIENCE WITH SERVE TUBES AT SEA.

The following extract is made from an article in the London *Marine Engineer*, February 1, 1891:

> Recently the steamer *Phra Nang*, built and engined by the Fairfield Shipbuilding and Engineering Company, Limited, had the boilers fitted with the "Serve" tubes for comparison with a sister ship in which plain tubes were fitted in the boilers. Both steamers proceeded out to China, where they are to be regularly engaged in trading, the sister vessel preceding the *Phra Nang*. It was anticipated that a favourable opportunity thus occurred for a first-class everyday working trial, and so it has proved, it being now reported to the builders of the steamers "that the Serve tubes have behaved quite satisfactorily throughout the voyage to China, and have shown an appreciable saving in the coal bill."
>
> As there have, however, been various circumstances which render an exact comparison impossible as to the actual performances of both vessels, the owners prefer that the *Phra Nang* shall run for three months on her station in China, as against the sister ship, before publishing a detailed report of the exact economy derived from the Serve tubes.
>
> Meanwhile it is satisfactory to Messrs. John Brown & Co., Limited, to have such a favourable report, confirming as it does the experience of the *Compagnie Générale de Navigation*, Lyons, which has now nine steamers constantly trading, in which the boilers are fitted with Serve tubes—that the tubes involve no practical difficulty in everyday use, and cause no delay or annoyance in cleaning. It has been alleged that in case of Serve tubes giving out they would be difficult to "stopper", but we understand that this presents no difficulty in practice, so that superintendent engineers need have no hesitation on that score for delaying to give the Serve tubes a trial.
>
> As regards the Serve-tubed boiler in use at Sheffield, we understand that further experiments are about to be made in the direction of demonstrating that with high accelerated draught such as the British Admiralty require, the diameter of the tubes, if of the Serve type, can be largely increased (the form of the tube providing greatly increased strength) in order to avoid the choking of the tube ends in the firebox, now

giving so much trouble in the case of plain tubes of small diameter, and that this improvement can be obtained whilst obtaining as great an evaporation per pound of fuel as is now the case with small ordinary tubes. Our readers will see that this latest departure in boiler-making promises to be one of the most important effected in recent years.

COMPARATIVE TESTS OF THE WARD BOILER AND THE COWLES BOILER.

In connection with these tests and their results, the following paragraph is quoted from that portion of the report of the Chief of the Bureau of Steam Engineering for 1890, referring to the machinery of the U. S. S. *Monterey*, building at San Francisco:

> As stated in my last annual report, the Bureau has decided, for the purpose of diminishing the machinery weights, to use tubulous boilers for about three-fourths of the boiler-power of this vessel. Of the boilers offered for tests in pursuance of the Department's advertisement and circular dated August 2, 1888, relative to coil, tubulous, or sectional boilers, only two were finally submitted for the prescribed trials, these being offered by William Cowles, of New York, and Charles Ward, of Charleston, W. Va. The results of the test were in favor of the boiler submitted by the latter, and in consequence a contract was entered into with Mr. Ward, July 15, 1890, for four of these boilers of a collective horse-power of 4,500 for the consideration of $60,000. By the terms of this contract the boilers are to be erected and fitted on board the *Monterey* within ten months from the date of contract.

The final report of the Board was submitted May 23, 1890, but the results were not made public in time to be included in the notes in General Information Series, No. IX.

Detailed reports of all the experiments conducted by the Board are given in full in the Report of the Chief of the Bureau of Steam Engineering for 1890. From these the following tables are taken:

Recapitulation of the results of the evaporative and calorimetric tests of the Ward boiler at Charleston, W. Va., December 18 *and* 19, 1889.

[NOTE.—All weights are given in pounds and all temperatures in degrees Fahrenheit.]

TOTAL QUANTITIES.

Duration of test, in hours, two of twelve hours each	24
Fuel (Nuttalburgh, New River) consumed	70,022
Refuse from fuel, in dry ashes, dust, and clinkers	3,389
Combustible consumed	66,633
Water fed to boiler, by tank measurement	461,884.6
Per cent. of the fuel in dry refuse, etc	4.84

AVERAGE QUANTITIES.

Temperature of feed water, t_1	50.4
Temperature of steam, by thermometer	364.33
Temperature of uptake	882.83
Temperature of atmosphere	72.48
Temperature of fire-room	75
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7+ pressure by gauge, in pounds, P	174.4
Air pressure, in inches of water	2

Rates of combustion.	Pounds of fuel.	Pounds of combustible.
Amount consumed per hour	2,917.58	2,776.38
Amount consumed per hour per square foot of grate-surface	55.05	52.38
Amount consumed per hour per square foot of heating surface	1.18	1.12

Vaporization, in pounds of water.	Per pound of fuel.	Per pound of combustible.
Apparent evaporation, by tank measurement, from a temperature t_1 and under a pressure P	6.596	6.932
Equivalent apparent evaporation, from and at 212°, and under atmospheric pressure	8.035	8.443
Actual evaporation, into steam of quality Q, from a temperature t_1 and under a pressure P	5.773	6.067
Equivalent actual evaporation, from and at 212°, and under atmospheric pressure	7.031	7.389
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from a temperature t_1 and under a pressure P	5.999	6.304
Equivalent potential evaporation, from and at 212°, and under atmospheric pressure	7.306	7.678

Recapitulation of the results of the evaporative and calorimetric tests of the Cowles boiler at navy-yard, New York, April 28 *and May* 8, 1890.

[NOTE.—All weights are given in pounds and all temperatures in degrees Fahrenheit.]

TOTAL QUANTITIES.

Duration of test in hours	24.15
Fuel (George's Creek) consumed	45,620
Refuse from fuel, in dry ashes, dust, and clinkers	6,327
Combustible consumed	39,293
Water fed to boiler by tank measurement	280,822.4
Per cent. of the fuel in dry refuse, etc	13.87

AVERAGE QUANTITIES.

Temperature of feed water, t_1	58
Temperature of steam, by thermometer	458.05
Temperature of uptake	965.91
Temperature of atmosphere	66.68
Pressure of steam at boiler, in pounds per square inch above a perfect vacuum, 14.7 + pressure by gauge, in pounds, P	174.7
Air pressure, in inches of water	2

Rates of combustion.	Pounds of fuel.	Pounds of combustible.
Amount consumed per hour	1,889.03	1,627.04
Amount consumed per hour per square foot of grate surface	40.19	34.62
Amount consumed per hour per square foot of heating surface	.93	.80

Vaporization, in pounds of water.	Per pound of fuel.	Per pound of combustible.
Apparent evaporation, by tank measurement, from a temperature t_1 and under a pressure P	6.156	7.147
Equivalent apparent evaporation, from and at 212°, and under atmospheric pressure	7.450	8.650
Actual evaporation, into steam of quality Q; from a temperature t_1 and under a pressure P	6.156	7.147
Equivalent actual evaporation, from and at 212°, and under atmospheric pressure	7.450	8.650
Potential evaporation, or evaporation had all the heat obtained from fuel been utilized in converting the water in boiler into dry saturated steam from a temperature t_1 and under pressure P	6.497	7.543
Equivalent potential evaporation, from and at 212°, and under atmospheric pressure	7.863	9.129

The arbitrary expression, *Q*, used in these tables to indicate the quality of the steam, represents the ratio between the amount of heat required to change one pound of water at the temperature of evaporation normal to the pressure in the boiler into steam of the quality of that in the boiler and the amount representing the latent heat of evaporation of dry saturated steam at the pressure in the boiler. In the case of moist steam, the percentage of moisture present may be obtained by subtracting *Q* from unity.

The value of *Q* in the case of the Ward boiler, as determined by taking the average of twenty-four calorimetric tests made at intervals of about one hour, was .875, and in the case of the Cowles boiler 1.067; that is to say, that, whilst the Cowles boiler furnished superheated steam, that from the Ward boiler contained 12½ per cent. of moisture.

The grate surface of the Ward boiler was 53 square feet, and the heating surface 2,473.5 square feet, a ratio of 1 to 46.7; the grate surface of the Cowles boiler was 47 square feet, and the heating surface 2,026.75 square feet, a ratio of 1 to 43.12; the weights of the boilers with contained water were, respectively, for the Ward boiler 13.85 tons, and for the Cowles boiler 11.55 tons. With the Ward boiler the closed fire-room system of forced draft was used, with the Cowles boiler the closed ash-pit system.

The various points to be reported upon by the Board, as enumerated in the original order from the Secretary of the Navy, were—

> * * * * the evaporative efficiency, the dryness of the steam, the weight of the boiler, the weight of the contained water, the ease of making repairs, the simplicity and interchangeability of parts, the space occupied, the ease of firing and regulating the feed, the suitability of working in battery, the durability and the capability of long-continued steaming without cleaning.

The conclusions of the Board as to the relative merits of the two boilers in these several respects, were the following:

> The evaporative efficiency is based upon the amount of water which, under the conditions of the tests, would be fed to all the boilers that the space allotted to the

ship will contain, this quantity being multiplied by Q. This method disposes of the question of the Secretary's order, "the dryness of the steam." We find these values to be relatively 1.086 for the Ward, and 1.00 for the Cowles.

The relative weights are as the water used as above, divided by the weight of all the boilers respectively, as given in our reports. These values we find to be 1.186 for the Ward and 1.00 for the Cowles.

The weight of the contained water is so nearly similar in both boilers that we give no values to the difference.

In the matters of accessibility, ease of making repairs, and simplicity and interchangeability of parts, we consider that the Ward boiler has a considerable advantage over its competitor. We think it scarcely necessary, however, to carry any spare parts with either boiler, except, perhaps, a manifold or two; 10 or 15 per cent. of all the tubes may be removed without materially affecting the economy at natural draft, or even under a small fire-room pressure.

In ease of firing they are equal. For the care of the feed, the Cowles has a great advantage over the Ward. We think one man could attend the feed of the six Cowles boilers as easily as he could two of the Ward, though fortunately the liability to damage from fluctuations of water level in the latter is small.

Both boilers will work well in battery, as both have done. In "durability and the capacity of long continued steaming, without cleaning", we think they are equal.

As the general result of the tests, it was considered that the Ward boiler had shown the better performance.

PREPARED SEA WATER FOR MARINE BOILERS; SOUTHAMPTON EXPERIMENTS.

An interesting and important test was made at Southampton, England, in August and September, 1890, of the method for the chemical preparation of sea water for marine boilers, proposed by Prof. Vivian B. Lewes, of the Royal Naval College, in his valuable paper "On the Formation of Marine Boiler Incrustations", read at the thirtieth session of the Institute of Naval Architects. The boiler used for the purposes of the experiment was a crane boiler at the Naval Construction Works, Southampton, placed at the disposal of Professor Lewes by Mr. J. H. Biles, general manager of the works. After steaming continuously for a month with water drawn from the Itchen half an hour before high tide, at which period analysis showed that the water was, to all intents and purposes, sea water with the addition of some mud in suspension, all the water fed into the boiler during the month having been chemically prepared, the boiler was opened on September 18, in the presence of a number of those interested in the experiment, and the interior was found to be in perfect order, with what looked like "the thinnest possible coat of whitewash."

The chemical process recommended by Professor Lewes consists essentially in adding sodic carbonate in the form of powder to sea water raised to the boiling point; the sodic carbonate reacting upon the calcic sulphate of the sea water, calcic carbonate and sodic sulphate are formed, the former of which precipitates as a soft powder, the latter remaining in solution; similarly, the magnesium salts are thrown down as carbonates, so that there remain in solution only the sodium salts, sodic chloride and sodic sulphate, neither of which begins to crystallize out at a lower saturation than between $\frac{6}{32}$ and $\frac{7}{32}$. In the practical application of the process at Southampton, the sea water was pumped, a ton at a time, into an egg-shaped vessel called the "precipitator", after which the "precipitator powder" was added, and exhaust steam was blown in to heat the water until a pressure of from 5 to 10 pounds was reached; under these circumstances a bulky precipitate of calcic and magnesic carbonate was formed, which was easily got rid of by filtering the water under pressure into the hot well. It was found that the reaction was facilitated by heating the water to the boiling point before adding the precipitator powder, as the deposit settled more quickly and threw less strain upon the filter.

The precipitator used was 6 feet 4 inches high and 3 feet in diameter, holding one ton of water; the time taken from running in the sea water to its delivery into the hot well was 1¼ hours, so that a precipitator of this size can be depended upon for the preparation of at least 12 tons of water per day. The prepared water has a saturation of $\frac{1}{32}$, and may be evaporated with perfect safety to a saturation of $\frac{5}{32}$. It is asserted that the presence of the salts in this prepared water makes it better for use in boilers than distilled water, the solvent action of which upon metals is well known. In expense, the system is said to be most satisfactory, the cost being only one-fourth that of distilling, and comparing favorably with the cost of fresh water in many ports.

In again referring to this subject of the chemical preparation of sea water for marine boilers, Professor Lewes says, in his recent paper on "Boiler Deposits", read at the last session of the Institution of Naval Architects:

> Professor Doremus, of the College of the City of New York, proposes to use sodic fluoride as a precipitant for the scale-forming constituents of sea water, as a smaller weight is required, and the action is more rapid and more perfect. The great objection has up to the present time been its cost, but I am informed that this has now been so far reduced as to bring it within the scope of extended commercial use; and, should it be used on a larger scale, the price could be readily brought much lower. Professor Doremus claims that the precipitation of the calcium and magnesium salts takes place with very great rapidity, that the sediment shows no tendency to cake or adhere to the sides of a hot vessel, and that it is less bulky than the precipitate formed by soda ash.
>
> In preparing sea water in the way I have proposed, every precaution must be taken to add slightly less of the precipitant than is necessary to entirely throw down the calcium and magnesium salts, as it is manifestly impossible in practice to guard against small quantities of sea water finding their way into the boiler either from leaky condensers or else being fed in by the engineer during some emergency, and if under these conditions any excess of the precipitant were present in the boiler, a bulky precipitate would be thrown down and cause trouble, although it would not bind into a solid scale.
>
> There is no doubt that, if Professor Doremus can so reduce the price of sodic fluoride as to enable it to be used for this purpose, it would be of great use, as the fluoride undoubtedly completes its action on the salts of magnesium and calcium more rapidly and thoroughly than the soda ash, and it would be easier, therefore, to so regulate the quantity added as to remove, say, five-sixths of the injurious constituents from the sea water without allowing any precipitant to enter the boiler.

BOILER DEPOSITS; DANGER TO FURNACE CROWNS FROM OIL.

INVESTIGATIONS BY PROFESSOR LEWES.

The following extracts, referring to the extreme danger to boilers resulting from the formation of organic or oily deposits on heating surfaces, and to the best means adapted for preventing such formations, are quoted from the valuable article by Prof. Vivian B. Lewes, on "Boiler Deposits", read at the last session of the Institution of Naval Architects (published in *Engineering*, May 1, 1891):

The first case which came under my notice, in which damage to boilers had arisen from this cause, was the case of a large ocean steamer, and through the kindness of Mr. Milton, chief superintendent engineer of Lloyd's, I was able to obtain samples of deposit from all parts of the boilers, and full particulars of the case. The steamer was a large one trading between Liverpool and Boston, averaged twelve days on the voyage, and was fitted with ordinary compound engines. She had three double-ended boilers, with three plain furnaces at each end and three combustion chambers in each boiler. The furnaces were plain in one length and connected at the back end to the tube plates, being flanged up inside the chamber, whilst the front-end plate was flanged inwards on to the furnace crowns. The furnace crown was ½ inch plate, and the front bottom plate $\frac{11}{16}$ inch, the working pressure being 80 pounds. The boilers are about five and a half years old, and have always been refilled with fresh water at the end of each run, both at Boston and Liverpool; whilst, as a rule, the waste on the voyage was made up by the use of about 70 tons of fresh water, but during the last voyage sea water was used for this purpose. Every four hours whilst under steam, 4 pounds of soda crystals were put in the hot-well, making about 2 cwt. during the run, the total capacity of the boilers being about 81 tons. For lubricating purposes, about seven pints per day of valvoline were used in the cylinders. When in port, the boilers were allowed to cool down, and the water was run off, and they were swept down with stiff brushes, and were afterwards sluiced out with a hose shortly before being refilled with fresh water.

No trouble occurred with the boilers until five voyages before the final collapse, when some of the furnaces began to creep in; they were stiffened with rings and stays, and on the succeeding voyages the whole of the furnaces got out of shape one after another. Examination of these boilers clearly showed that they had never been very heavily scaled, as in parts of the boiler where it would have been impossible to get at them to clear them out, no signs of heavy incrustation were to be found, and the absence of marks of scaling tools also showed that they had never been allowed to get very dirty. On the furnace crowns, where they had collapsed, there was only a slight white scale, not more than $\frac{1}{64}$ inch in thickness, whilst on the bottom of the furnaces there was a brown oily deposit $\frac{1}{16}$ inch in thickness, which in other parts of the boilers increased to between ⅛ inch and $\frac{3}{16}$ inch. I obtained from Mr. Milton samples of the thin scale from the top furnaces, and of the deposit from various parts of the boiler, and also specimens of cut-out portions of the boiler plates, Liverpool water, valvoline, and soda crystals put into feed water, and of all these analyses were made.

The boiler plates were as good as the day they were put in, and showed no structural signs of having undergone any change, whilst the analyses of the Liverpool water and the soda crystals used showed that they could have taken no part in the action which had led to collapse.

I.—*Valvoline.*

The valvoline on analysis gave:

Vegetable and animal oil	nil
Mineral oil	100 per cent.
Acids (free)	nil
Boiling point	371 deg. C.
Specific gravity	.889

II.—*Scale from furnace.*

	From top.	From below.
Calcic sulphate	84.87	59.11
" carbonate	5.90	6.07
Magnesic hydrate	2.83	11.29
Iron, alumina, and silica	2.37	2.85
Organic matter and oil	3.23	19.54
Moisture	0.80	1.14
Alkalis	nil	nil
	100.00	100.00

III.—*Deposit from tubes.*

	Scale on tubes.	Deposit above scale.
Calcic sulphate	50.92	11.60
" carbonate	4.18	0.82
Magnesic hydrate	14.12	22.21
Iron, alumina, silica, &c.	7.47	9.14
Organic matter and oil	21.06	50.20
Moisture	1.17	4.23
Alkalis	1.08	1.80
	100.00	100.00

IV.—*Deposit from bottom of boiler.*

Calcic sulphate	22.52
" carbonate	nil
Magnesic hydrate	7.09
Silica, alumina, and iron	34.85
Organic matter and oil	27.95
Moisture	5.79
Alkalis	1.80
	100.00

On careful examination of the organic matter and oil present in these deposits, it was found that quite one-half of it was "valvoline" in an unchanged condition, which had collected round small particles of calcic sulphate.

A consideration of these analyses, at first sight, yields no clew as to the cause of the collapse, the scale upon the furnace tops being not only free from oil, but perfectly harmless both in quantity and quality; but on going more deeply into the question, it is evident that this scale can not be in the condition in which it was originally formed, as the deposits from both top and bottom of tubes, from the bottom of the furnaces, and from the shell of the boiler, are all rich in oily matter; and it is impossible that, during this deposition, the furnace tops could have escaped whilst all other parts of the boiler became coated with it. Experiments, however, reveal the actions which had been at work and led to the formation of the deposit, and its absence upon the injured portions of the plates.

The pressure at which the boilers were worked was 80 pounds, corresponding to a temperature of 155 deg. Cent., or 311 deg. Fahr., which is so far below the boiling point of the valvoline that it was evident that it had not distilled over in the ordinary way, and experiments were made to see if it could be distilled in steam at a lower temperature. A retort containing valvoline was carefully heated over a sand bath, its temperature being ascertained by a thermometer, and steam was then blown through it, with the result that at 248 deg. Fahr., or 120 deg. Cent., the water became "greasy" and the oil commenced to pass over with it.

This experiment is, I think, important, as it shows that in testing the capabilities of a lubricant, the fact that it has a boiling point well above the temperature of the steam is no guarantee that none of it will find its way into the boiler. Having thus entered the boiler, the minute globules of oil, if in great quantity, coalesce to form an oily scum on the surface of the water, or, if present in smaller quantities, remain as separate drops, but show no tendency to sink, as, their specific gravity being .889, they are lighter than the water, and the difference in gravity is probably even greater at the temperature existing in the boiler.

Slowly, however, they come in contact with small particles of calcic sulphate and other solids separating from the water, and sticking to them, they gradually coat the particles with a covering of oil, which in time enables the particles to cling together or to the surfaces which they come in contact with. These solid particles of calcic carbonate, calcic sulphate, &c., are heavier than the water, and, as the oil becomes more and more loaded with them, a point is reached at which they have the same specific gravity as the water, and then the particles rise and fall with the convection currents which are going on in the water, and stick to any surface with which they come in contact, in this way depositing themselves, not as in common boiler incrustations, where they are chiefly on the upper surfaces, but quite as much on the under sides of the tubes as on the top, their position being regulated by whether they come in contact with the surface whilst descending or ascending.

The deposit so formed is a wonderful non-conductor of heat, and also from its oily surface tends to prevent intimate contact between itself and the water. On the crown of the furnaces this soon leads to overheating of the plates, and the deposit begins to decompose by the heat, the lower layer in contact with the hot plates giving off various gases which blow the greasy layer, ordinarily only one $\frac{1}{64}$ inch in thickness, up to a spongy, leathery mass often $\frac{1}{4}$ inch thick, which, because of its porosity, is an even better non-conductor of heat than before, and the plate becomes heated to redness, and, being unable to withstand the pressure of steam, collapses. During the last stages of this overheating, however, the temperature has risen to such a point that the organic matter, oil, &c., present in the deposit, burns away, or, more properly speaking, is distilled off, leaving behind, as an apparently harmless deposit, the solid particles round which it had originally formed.

Such a deposit is more likely to be produced with boilers containing fresh or distilled water, as the low density of the liquid enables the oily matter to settle more quickly, whilst with a strongly saline solution it is very doubtful if this sinking point would ever be reached; it is evident also that, when oil has found its way into the boiler and is causing a greasy scum on the surface, the most fatal thing that can be done is to blow off the boilers without first using the scum cocks, because as the water sinks, so the scum clings to the tops of the furnaces and other surfaces with which it comes in contact, and, on again filling up with fresh water, it still remains there, causing rapid collapse.

A very remarkable instance of this is to be found in the case of a large vessel in the eastern trade, in the boilers of which an oil scum had formed. The ship having to stop some days at Gibraltar, the engineer took the opportunity of blowing out his boilers, and refilling with fresh water, with the result that before he had been ten hours under steam, the whole of the furnaces had come in.

* * * * * * *

The next point I attempted to determine was the effect which these oily deposits had in allowing excessive heating of the plates to take place and retarding the heating of the water. A clean iron vessel was taken, and a known volume of water placed in it, and heated by a carefully regulated Bunsen flame, the water being raised to the boiling point in ten minutes; this experiment was repeated a second time with the same result, and the vessel was then lined with a coating of deposit found in the bottom of the boilers which had collapsed, and rendered binding by admixture with a small trace more valvoline. This coating was laid on $\frac{1}{16}$ inch in thickness, and the former experiment repeated, the same flame being used and the same volume of water taken, with the result that it took fifteen minutes before the boiling point was reached, showing that, even if no damage resulted to the plates from overheating, such a deposit would cause a large increase in the fuel used.

In attempting to ascertain to what extent extra heating of the plate took place from this cause, I employed a series of substances of known igniting and melting point, raised the water in the various vessels to the boiling point, and then brought the clean bottom of the vessel in quick contact with the test substance, and took the results as indicating the temperature of the exterior of the plates.

		Deg. Cent.	Deg. Fahr.
Clean vessel	Sulphur did not melt	below 115	= 239.
Coated vessel	Sulphur melted but did not inflame	above 115	= 239.
		below 250	= 482,
	Gun cotton ignited	above 200	= 392.

So that the $\frac{1}{16}$th of deposit caused with a slow heat a rise in temperature of the plate from under 115 deg. Cent., or 239 deg. Fahr., to over 200 deg. Cent., or 392 deg. Fahr. It is manifest, however, that the fiercer the heat the more marked will this overheating become, and in the next series of experiments the Bunsen flame was replaced by an atmospheric blowpipe, and the temperature attained tested in the same way as before.

		Deg. Cent.	Deg. Fahr.
Clean vessel	Sulphur did not melt	below 115	= 239.
Coated vessel	Gun cotton ignites	above 200	= 392.
	Tin melts	" 228	= 444.4
	Sulphur ignites	" 250	= 482.
	Lead melts	" 334	= 633.
	Zinc melts (just)	" 423	= 793.4

Whilst, on replacing the atmospheric burner by an oxy-coal gas flame, I found no difficulty in fusing a hole in the bottom of the vessel, which was made of thin wrought-iron plates, showing that a temperature of 1,500 deg. Cent. = 2,732 deg. Fahr., had been attained, and it is therefore manifest that with the fierce heat existing in the boiler furnaces, given an oily deposit only $\frac{1}{16}$ inch in thickness, the plates will readily be heated to a temperature at which they are totally unable to withstand a pressure of 80 pounds of steam, and collapse of the furnace crowns must follow.

The great points to be sought in a good lubricating oil are that it shall be a pure mineral oil, and that its boiling point shall be well above any temperature likely to be attained in the cylinder. Oils satisfying these requirements can readily be obtained, but users of lubricants must remember that, in order to obtain them free from any constituents of dangerously low boiling point, expensive processes have to be resorted to, which must of necessity increase the price of the oil, and that it is useless to expect to obtain a really good lubricant at a low figure. The great advantages of a good mineral oil can not be too strongly insisted on, and any lubricant containing animal or vegetable oils to give it body should be unhesitatingly discarded.

* * * * * * *

In conclusion, I will briefly recapitulate the means which seem to me best adapted for preventing the formation of the dangerous organic and oily deposits I have considered in this paper, and these are:

I. Filtration of condenser water through a coke column.
II. Free use of the scum cocks.
III. The use of water of considerable density rather than of fresh water.
IV. The use of pure mineral oil lubricants in the smallest possible quantity.

YARROW'S TUBULOUS BOILER.

After some years of experimental work, Yarrow & Co. have introduced a form of tubulous boiler, which will probably altogether supplant the boiler of locomotive type heretofore used in the Yarrow torpedo-boats. The first of these boilers for practical use was fitted in a second-class Argentine torpedo-boat tried December 23, 1890, with most satisfactory results. The boat is one of several supplied by Messrs. Yarrow to the Argentine Government, alike in all respects except as to the boilers, the others being supplied with locomotive boilers. The average speed of the other boats was about 17 knots, whilst the one with the new type of boiler made 18.1 knots under precisely similar conditions.

The chief point of difference between this boiler and other boilers of this class, such as the Thornycroft boiler, or Cowles boiler, is that the tubes are straight instead of curved. These tubes are arranged in two sets, running from two semi-cylindrical drums at the bottom, between which the fire-grate is situated, to a common cylindrical steam chamber at the top. The accompanying cut (Pl. II.), copied from *Engineering*, January 16, 1891, conveys a good idea of the design. A smoke-jacket surrounds the drum and tubes; the products of combustion pass from the grate through the nests of tubes on either side and then to the uptake at the top. The water level is carried at about half the height of the upper drum, so that the tops of the tubes are always covered with water. The illustration shows larger tubes fitted at the back end for circulation, but it has been found that these are unnecessary, as on account of the reduction of temperature of the products of combustion in passing through the nests of tubes, the water will rise in the inner tubes exposed to the hottest gases, and will descend through the outer tubes, which are not subjected to such high temperatures.

The advantages claimed for this boiler are simplicity, lightness, and that it is easy to repair. It may be observed that the upper chamber is made in two parts bolted together, and that the lower tube-sheets are bolted to the drums; by dividing the chambers at the flanges, the straight tubes become accessible for cleaning. It is reported that no trouble has been experienced from leaky tubes with this boiler, nor from priming. As to its durability the makers are confident, having had boilers of this general type at work experimentally for several years before introducing them into service.

The torpedo-boat already referred to, in which this boiler was tested in December last, was of about 15 tons displacement, 60 feet in length by 9 feet 3 inches beam, with triple-expansion engines of about 250 I. H. P. The boiler for this boat was 6 feet in length, and with an upper chamber of 20 inches diameter.

YARROW'S TUBULAR STAY.

Much trouble has been experienced in some vessels having a number of locomotive boilers grouped closely together, from leakage of the water-space stays, owing to the sudden and great variations in the temperature of the furnace. With the ordinary riveted stay it is impossible to repair these leaks unless there is sufficient room to allow workmen to get in between the boilers. Having this experience in view, to save space, Messrs. Yarrow & Co. have introduced the tubular stay illustrated in Pl. II. (see *Engineering*, November 7, 1890), which is so designed that by means of the special tools, shown also in the cut, both ends of the stay may be secured in the plates by an operator working inside the furnace.

The stays are of soft steel, and are made with a hole of two diameters, the larger of which extends the greater part of the length. They are screwed into the plates in the usual way, after which a drift that passes freely through the part of the hole of larger diameter is used to expand the farther end of the stay, where the tube is of smaller diameter; a similar operation is performed with a larger drift at the inner end of the stay, and thus both ends are fitted tightly into the plates. The system of expanding stays into the plates is considered preferable to riveting over the ends, even when both ends are accessible, and is reported to have been adopted in the locomotive boilers of the North London Railway for some years, the method employed differing only from that of Messrs. Yarrow in having the drifting performed from both ends instead of from one end only. As illustrative of the strength obtained by means of this system, experiments have been made with ⅜-inch plates, stayed in this way with stays of 1 inch diameter over the thread, spaced 4 inches apart between centres, which stood bursting pressures of from 1,600 to 1,700 pounds per square inch, giving way in every case by parting of the stay.

ORLANDO BROS.' TUBE-SHEET EXPANSION-RING FOR FORCED DRAFT.

This device for preventing the starting of tubes in the tube-sheets when exposed to forced draft is described in a letter from Messrs. Orlando, of Leghorn, addressed to the editor of the London *Engineer*, and published with the accompanying illustrations (Pl. III.) in the issue of that paper of May 1, 1891. The letter was called forth by the valuable paper by Mr. Yarrow, read before the Institution of Naval Architects, "On the Construction of Boilers Adapted to Forced Draught", which was published in *The Engineer*, March 20, 1891.

The invention promises to prove of great usefulness. It has been tried, in the two forms shown in Pl. III., with most satisfactory results, by Messrs. Orlando, in two boilers of locomotive type. The first arrangement (Fig. 1) was intended for an experimental torpedo-boat, and worked without giving any trouble with 6 inches air pressure and 140 pounds of steam. A copper ring, U-shaped in cross-section, was fitted to the back tube sheet. In the second arrangement (Fig. 2), the shape of the copper ring was slightly changed, as shown in the cut. This was fitted to a boiler supplying steam to a quadruple-expansion engine at a pressure of 180 pounds, and has been worked continuously for ten days at a time, with 2 or 3 inches air pressure, and subjected to numerous variations in the fire, without the slightest leakage either in the tube-sheets or in any other parts of the boiler.

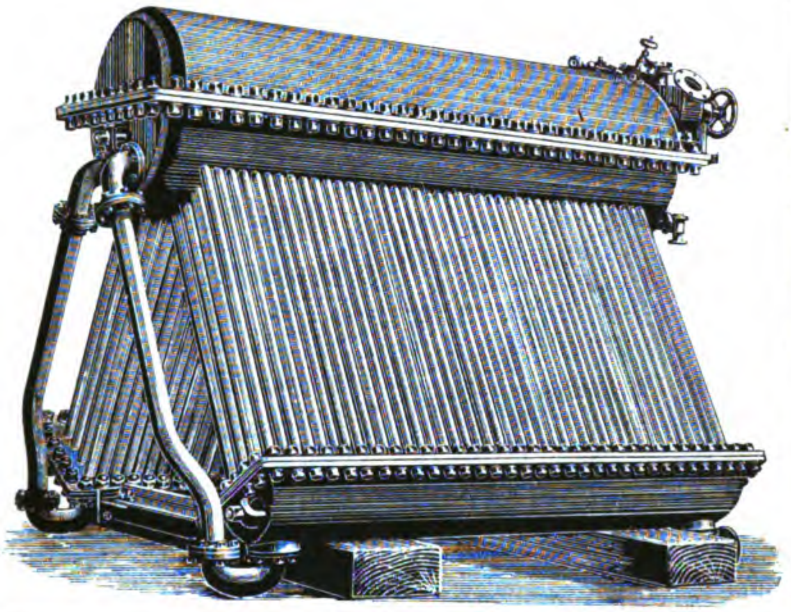
It may be seen that this invention aims to secure, what Mr. Yarrow has insisted upon as a quality of the very greatest importance in boilers intended for forced draft, namely, elasticity. Messrs. Orlando lay great stress upon this point in their letter; they point out that there is no way to explain why torpedo-boat boilers should leak with 5 inches or 6 inches air pressure whilst a common railway boiler will stand 8 inches or 10 inches, except by the consideration of the difference in elasticity between the two types, the advantage in this respect lying with the railway boiler on account of the greater length of its tubes.

It has been observed that leakage in tube-sheets usually happens when the fires are allowed to ease down after having been rapidly forced, and not when the boilers are actually being pushed to their maximum performance, which would seem to indicate that the leakage is the result not so much of overheating of the tube sheets as of a "crawling" of the tubes due either to distortion of the sheets or to contraction of the tubes. These considerations have led to the introduction of this device, and whilst the point referred to by the Engineer-in-Chief of the British Navy, in the course of the discussion of Mr. Yarrow's paper, should not be lost sight of, that the performance of a single boiler is always better than the performance of a group, the trials already made by Messrs. Orlando indicate that the invention is one of importance.

KIRK'S EVAPORATOR; NEW TYPE, AS FITTED TO S. S. DAMASCUS.

The accompanying plate (Pl. IV.) p. 137 gives two elevations, front and side, of one end of Kirk's evaporator, as fitted to the steamer *Damascus* by Messrs. R. Napier & Son, of Glasgow, together with a cut showing the location of the evaporator with reference to the boilers. The design recommends itself by its extreme simplicity. The boilers of the *Damascus*

YARROW'S TUBULOUS BOILER



YARROW'S TUBULAR STAY

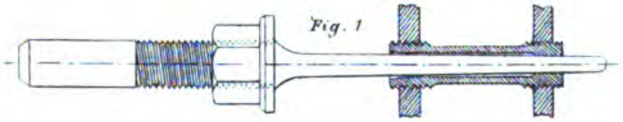


Fig. 1

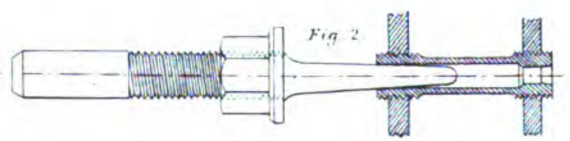


Fig. 2

PLATE III.

Fig 1.

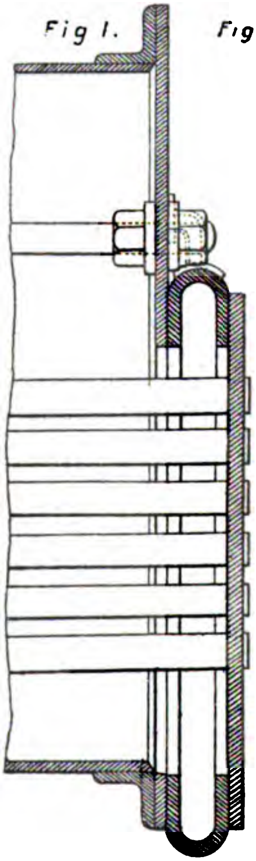
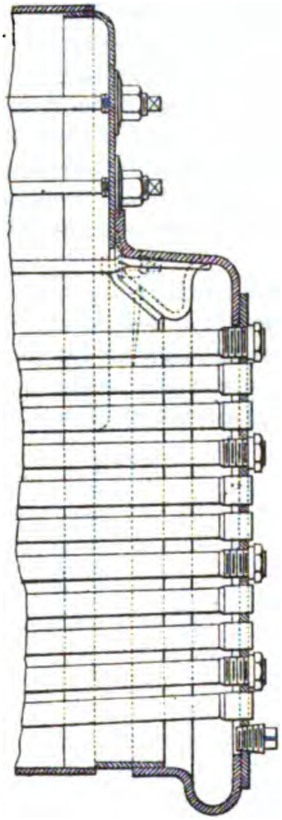


Fig 2.



are double-ended, with the base of the smoke-pipe nearly the same distance from the two ends. The evaporator, cylindrical and of about the same length as the boilers, lies above and between them in the uptake. The attachments are only those shown in the illustration, a gauge glass, two gauge cocks, a steam stop valve, a safety valve, a check valve, and a blow valve. A manhole is provided for cleaning, which becomes a very simple operation, the interior presenting an unbroken cylindrical surface. The pressure to be maintained may be determined by setting the safety valve. Steam may be delivered either to the condenser or to the L. P. valve-chest. It has been found on board the *Damascus* that some priming occurs in delivering directly to the condenser, the most efficient working being obtained by delivering to the L. P. cylinder, with a pressure maintained in the evaporator of from 10 to 20 pounds. The evaporator is fed from the sea by one of the auxiliary pumps, and the best results are obtained by maintaining a constant feed and a constant blow; it is worthy of note that in case of shortage of water in the evaporator, the comparatively low heat in the uptakes would not be sufficient to cause injury.

This evaporator, after forty days' continuous service in the *Damascus*, during which time it supplied all deficiencies of feed to the two double-ended boilers of the vessel, was found to have its water surface coated with a deposit of scale of about $\frac{1}{8}$ inch thickness, which was easily detached. The illustrations are copied from *Annales Industrielles*, February 15, 1891.

FORCED DRAFT.

MARTIN'S SYSTEM OF INDUCED DRAFT.

TRIALS AT PORTSMOUTH DOCKYARD.

A series of trials of Martin's system of induced draft, by means of a fan at the base of the smoke-pipe, was concluded at the Portsmouth (England) Dockyard, August 9, 1890. The boiler used was of the locomotive type, and had been taken out of H. M. S. *Polyphemus*, after having been condemned. The first experiments made upon this boiler with induced draft, those of March 20, April 2, and April 10, 1890, the results of which were given in General Information Series, No. IX., 1890, p. 70, were made with the old tubes, but these were found to have been too much injured during the *Polyphemus* trials to withstand the strains produced, so they were withdrawn and the boiler entirely re-tubed.

The following table gives the results of the trials made after the re-tubing, four of which, each of 8 hours' duration, form a progressive series, whilst the fifth, of 96 hours' duration, was for testing endurance:

	Date of trial (1890).				
	July 25.	July 26.	July 28.	Aug. 1.	Aug. 5 to 9.
Duration of trial, hours	8	8	8	8	96
Steam pressure	74.3	74.08	76.56	74.3	74.2
Air gauge, smoke box	.57	1.25	1.55	2.06	1.27
Air gauge, eye of fan	.85	1.43	1.87	2.5	1.56
Air gauge, base of pipe	.25	.26	.57	.54	.53
Temperature, feed	60.9	60.4	60.9	62	62.1
Temperature, atmosphere	68.8	67.9	68.1	67.3	69.9
Revolutions, engine	84.6	101.3	124.9	139.8	104
Revolutions, fan	376.4	445	534.7	636.9	485
Pounds of water evaporated per pound of coal, at actual temperatures	10.02	9.3	9.09	8.3	9.64
Pounds of water evaporated per pound of coal, from and at 212°	11.58	10.75	10.71	9.58	11.13
Pounds of coal per square foot of grate per hour	30.69	42.7	49.95	63.7	40.4
Pounds of water evaporated per square foot of grate per hour, at actual temperatures	307	397	454	528	389.6
Pounds of water evaporated per square foot of grate per hour, from and at 212°	355	459	525	610	450.4
Pounds of water evaporated per square foot of heating surface per hour	5.8	7.5	8.58	10	7.36
I. H. P. of engine, approximate	337	435	497	579	426

The area of the fire grate was 20.77 square feet. The boiler had 258 tubes, of 1⅞ inches outside diameter, and of a length between tube-sheets of 8 feet 6 inches. The average power required to drive the fan was 1.38 per cent. of the I. H. P. developed by the engine. Observations were taken every half hour. The rate of steaming was governed by the rate of speed at which the fan was driven. It may be seen from the table that the highest rate was on August 1, when an average rate of combustion of 63.7 pounds of coal per square foot of grate per hour was maintained for 8 hours. The coal used was Harris's Deep Navigation. No priming was observed during any of the trials. The mean temperature registered in the middle of the tubes was 810°. At the conclusion of the trials, the apparatus, tubes, tube-sheets, and fire-grates were all found to be in excellent condition.

A series of trials was then undertaken with the same boiler under similar conditions, but with the substitution for induced draft of the closed fire-room system of forced draft. Concerning these later trials, the results of which were not published, the London *Times*, November 10, 1890, may be quoted as follows:

> After the completion of experiments with Mr. Martin's system of induced draught at Portsmouth upon one of the discarded locomotive boilers of the *Polyphemus*, which lasted from the 25th of July until the 9th of August last, it was determined for purposes of comparison to carry out a series of similar trials upon the same boiler with forced draught. These experiments have just been concluded. The only mishap that occurred was the temporary breakdown of the large fan which supplied the air from outside the boiler room. The naval authorities decline to furnish the results of the several trials for comparison with the *data* already published in the

Times. It is, however, understood that, while the boiler tubes passed successfully through both ordeals, the steaming with induced draught gave superior evaporation per pound of coal and square foot of heating surface. Engineers find it difficult to explain how a type of boiler which failed utterly in the *Polyphemus* should not only have passed successfully through these exceptional endurance trials, but have proved its superiority to the pattern at present fitted in Her Majesty's ships. Since its removal from the ram the boiler was made to take its feed through convolutions at the top, by which the water was warmed, instead of being received at the bottom, whereby chills were produced. This and better stoking probably prevented leakage.

In this connection, significance attaches to certain remarks by the Engineer-in-Chief of the British Navy, made in the course of the discussion of Mr. Yarrow's paper " On the Construction of Boilers Adapted to Forced Draught", before the Institution of Naval Architects. The following extracts are made from the report of this discussion in *Engineering*, April 3, 1891:

Every engineer would admit that in working with a single boiler the difficulties were considerably less than with a group, on account of complication attending feeding arrangements in the latter case. * * * In regard to keeping the temperature of the water at the bottom and the top of the boiler more equable, the speaker found the most effectual way of doing that was to take the feed pipe above the furnace and point it up among the tubes. * * * The speaker was inclined to think that a vacuum in a smoke-box was likely to do very much less harm to the tube-plate than an equal pressure in the stoke-hold, because in the one case the air goes through the fire and forces all the products of combustion against the tube-plate. In the other case the streams of the products of combustion, which have been formed by the vacuum in the smoke-box, are drawn through the tubes. It has been said, the speaker continued, that this was a question of difference of pressure entirely, but some recent experiments which had been made at Portsmouth threw a different light on the subject. An old locomotive boiler, which had formed one of a group of ten in a ship, was used for these experiments. These boilers had originally failed when on board ship, and had to be removed. In the experiment referred to the boiler was worked at its full power and did not give the least trouble. The speaker contended that this proved what he said at first, namely, that one boiler will work much better than a group. Mr. Yarrow here asked whether the boiler was tried with fresh or condensed water. Mr. Durston replied that it was fresh water, not condensed water. Mr. Yarrow pointed out that it was hardly a parallel case. Mr. Durston observed that to that extent it was not; and he went on to draw a comparison between induced draught and forced draught. The experiments showed that the tubes were as much choked and the tube-plates and fires as dirty after twelve hours of forced draught as they were after thirty-six hours of induced draught.

THE HOWDEN CLOSED ASH-PIT SYSTEM, AS APPLIED TO THE S. S. CITY OF PARIS.

The following description and accompanying illustrations (Pl.V.) are copied from an article in *Engineering*, May 8, 1891, descriptive of the repairs and alterations made in the machinery of the *City of Paris* since the accident to that vessel, March 23, 1890:

An important alteration has been made in connection with the generation of steam. Formerly the nine boilers were worked under the closed strokehold system of forced draught, but during the time the vessel was laid aside it was superseded by Howden's system. Extensive structural alterations were necessary, as this latter arrangement does not require a closed stokehold and necessitates a different type of furnace door and additional appliances on the front of each boiler.

It may be stated at the outset that there are nine double-ended boilers arranged in triplets in separate water-tight compartments. The diameter of each boiler is 15¼ feet and the length 19 feet, there being in all fifty-four furnaces of a mean diameter of 3 feet 10 inches. The tubes are 7 feet 6 inches long, 2⅝ inches in diameter, and as in each boiler there are 1,056 tubes, the heating surface totals 50,040 square feet. Mr. Howden has shortened the fire-bars by 9 inches, and has thereby reduced the grate area from 1,293 to 1,026 square feet. At the sides, too, Mr. Howden has put plates fitting closely into the corrugations of the flue.

In describing the system of forced draught, * * * it will perhaps be better to begin with the fans, following the course of current of air to the furnace. As in the original arrangement, the fans are placed on the main deck with square trunks, which are continued above the promenade deck, there being there constructed a large square chamber having a covering on hinges to admit the entrance of a draught when the vessel is steaming. There are four of these chambers on each side of the ship; at the foot of each there are a couple of fans, and one fan in the case of the forward and after chambers, making twelve in all, so that from each side a current of air is sent down, and passes along the front of each series of three boilers placed athwartship. The fans are by B. F. Sturtevant, of Boston. They are each 6 feet in diameter, and each are driven up to a maximum speed of 430 revolutions by a double engine by the same maker. The cylinders are 7 inches in diameter and have a stroke of 5 inches. The distribution of steam to both cylinders is effected by a single piston valve placed at the side. The cranks are placed diametrically opposite, which enables the valve to send the steam in at the bottom of the one cylinder and at the top of the other alternately. The entire engine is inclosed, to prevent the bearings being affected by dust, but all parts are accessible when the door is opened. The regulation of the engine is by a shaft governor forming part of one of the pulleys, and acting through the eccentric to change the throw of the valve and vary the cut-off from 0 to ⅞ stroke. The engines, of course, are coupled direct to the fan-shafts. Each fan discharges downwards through a square trunk between the main and lower deck, from the bottom of which a rectangular air pipe is led downwards and thence along the front of the uptake of the boilers immediately above the top of the boiler tubes. There is a fan at each side of the ship as we have already indicated, and they blow the one into the port and the other into the starboard end of the rectangular pipe (Figs. 1 and 2).

As is well known, this system of forced draught has a series of air-heating iron tubes placed vertically at the base of the uptake, the bottom tube-plate of the air heater containing these tubes being only 1 inch or 2 inches above the upper row of the boiler tubes (Figs. 3 and 4). The tubes in the heaters in the *City of Paris* are 3 inches in diameter, and are each 34 inches long. This air heater extends nearly across the whole width of the front of the boiler above the tubes (Fig. 3). The rectangular air pipe passes along immediately in front of these air heaters and is continuous across the three boilers (Figs. 1 and 2). There is a rectangular opening at the vertical centre line of each of the boilers, to allow the forced draught to pass from the main pipe into the air heater (Fig. 1). After passing through amongst the tubes the heated air flows down at each side of the outer smoke-boxes to an air reservoir which encircles the upper half of the furnace front, occupying the whole space upwards to the bottom of the smoke-boxes (Figs. 3 and 4). This air reservoir is quite separated from the smoke-boxes by an air-tight sheet-iron casing. From this reservoir the air passes to the furnaces, part going into the ash-pit and part into the flue above the fire, the supply to each place being regulated by separate valves.

There are two valves admitting the air to each ash-pit, placed on each side of the furnace at the bottom of of the reservoir. The valve for admitting the air above the fires slides on a flat plate separating the air reservoir above from the space between

PLATE V.

Fig

Fig. 2.

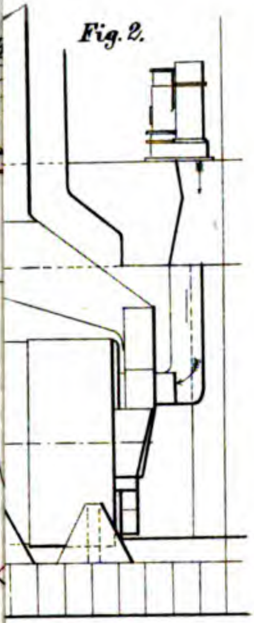
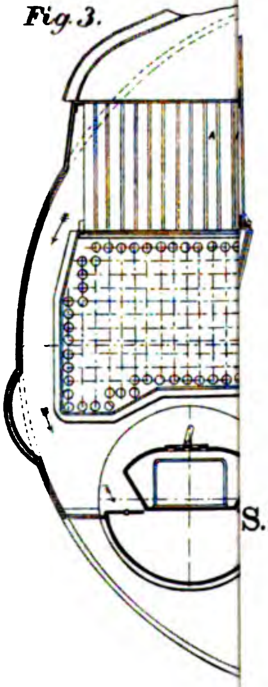


Fig. 3.



HOWDEN'S
FORCED DRAFT
ARRANGEMENT

S.S. CITY OF PARIS.

the outer and inner furnace doors (Fig. 4). These swing together on one hinge, and when the door is shut the air passes between the outer and inner doors, maintaining a pressure in the space as well as around the interior of the furnace front. From this pressure space between the doors the air is admitted to the furnace through a number of air-distributing boxes, perforated on the side against the fire with small holes, ⅜ inch in diameter, of a given aggregate area, according to the required rate of combustion. The air passes on to the surface of the fuel under combustion. The system, it will be seen, preserves the cast-iron furnace fronts from injury by the heat of the fires. Each ash-pit has a closed door, and the air pressure is maintained underneath the bars according to the revolutions of the fans, or the greater or less opening of the valves admitting air. These valves are throttle valves each worked on a central axis in the usual way, but the disc being square.' The spaces between the furnace bars are ⅜ inch wide, and the air when passing through meets the air from the upper valve.

The temperature of the air in the reservoir is generally about 210 deg., and the pressure of course varies according to the speed at which the fans are run. On the trial on the measured mile in the Firth of Clyde on Friday, 1st instant, the fans only worked up to 370 revolutions, although early in the following morning they attained a speed of 430. The pressure at the former speed was 1¼ inches in the reservoir and ⅜ inch above the fire and in the ash-pit.

LIQUID FUEL.

USE OF PETROLEUM REFUSE, OR RESIDUUM.

The most notable utterance on the subject of liquid fuel during the past year was the paper read by Capt. W. V. Carmichael before the Shipmasters' Society, of London, February 13, 1891, on "Liquid Fuel in Ocean Steamers." It is to be found in the London *Shipping World*, March 1, 1891. The following extracts are made:

* * * I shall describe the fuel used, so far with perfect success, after which I shall describe the methods of using it. In Russia it is called "*astacki*", in England and America it is generally known as "*residuum.*" It is the residue of crude petroleum when all the volatile or lighter oils are distilled from it. It is perfectly non-inflammable, until heated to 350 degrees, and consequently quite safe to use and carry in large quantities; it has no smell, in consequence of not giving off gas until obtaining the required heat; it does not deteriorate by being stored in tanks, exposed to the air, nor does it evaporate perceptibly; it is not detrimental to metal tanks, the inside skin of the vessel, nor any of the ordinary receptacles.

* * * The fires are completely under control of the engineer on watch; he can regulate them so as to have any pressure of steam he wants without being dependent on his firemen; in heavy weather his steam is as much under control as in fine weather; it does not need any extraordinary attention, as when once the burners are set away properly, they will run without any trouble for days, and maintain steam almost without variation, providing the engines are kept in the same gear, and feed water is used in the regular way. This I have proved on several voyages during the last eight months, notably on my first voyage from Talara Bay, Peru, to Valparaiso, Chile, in the steamship *Ewo;* the pressure on the boilers was maintained steadily at 158 lbs. for seven days, and under most unfavourable circumstances, as in the first place it was our first ocean trip with oil fuel, and the ship was being driven full speed into a head sea all the time. For the information of engineers, of whom I see a rather formidable aray, I must here state that during that time, in order to compensate for the loss of fresh water occasioned by the use of the steam jet, together

with the ordinary leakage from glands, &c., the boilers used 10 tons of fresh water; the boilers, being run up in Talara Bay, showed on being tested in Valparaiso, after the seven days' run, a density of 7 ozs. of salt; the engines developed 450 I. H. P. The contraction and expansion of the boilers by using oil fuel is reduced to a minimum, as in getting up steam you can do so as gradually as you wish. There are no fire doors to open every time you coal your furnaces; your fires never need cleaning; consequently, that fruitful cause of loss of steam and contraction of the boiler is done away with, and not having to force your fires to regain what was lost in that operation you avoid the consequent expansion of the boiler; thus the life of a boiler fired with liquid fuel must from these circumstances alone be longer than a boiler fired with wood or coal. Liquid fuel, if applied with steam, does no injury to the crown sheets, back connections, or combustion chamber of a boiler; tubes do not need sweeping often, as with coal, for instance; the tubes in the steamer I mentioned were only swept once in six months, and even then were not dirty; there is no dust or grit, as there are no ashes; therefore the saving of labor and paint are considerable items in the engineers' department.

* * * Of course there are certain expenses entailed by the use of oil fuel; for instance, the furnaces would have to be fitted for burning oil, the average expense being about £30 per furnace. You would have to make your side bunkers oil-tight, and fit them with the necessary connections; also some alterations might have to be made about the ballast tank; a small steam pump would have to be fitted, together with a supply tank, and the necessary connections for steam and oil. These expenses would be done away with entirely, if the boat were originally built for oil fuel, as in the boat I have just commanded.

* * * For many reasons oil fuel is of more value to torpedo boats and ships of war than it even is to merchant steamers, being capable of such compact storage; for you are able to utilise parts of the ship that are now useless, with the additional advantage of keeping your fuel completely out of gun fire. Again, a most important question arises, and one which was asked in Parliament, but if I remember rightly very ably shuffled out of—"How are we to fuel our men-of-war at sea during a blockade?" To either a marine engineer or a seaman the importance of this question will present itself. Last summer's naval manoeuvres went to prove the difficulty, for although, under exceptionally favourable circumstances, men-of-war were coaled at sea, the Admiralty and all the naval officers who witnessed the operation know that this means of obtaining fuel could not be depended on, and, besides, the modern man-of-war is not constructed for rapid coaling. One of two things would have to be done in the event of a blockade; either the ships would have to be relieved or else they would have to be fueled at sea. If the former were adopted, it would mean more ships and more men; and if the latter, it would mean more coals, more men, more boats, and more fine weather than we generally get. The reason I say more coals is because no mention has been made of the coals which went overboard when coaling at sea was tried. The reason I mention more boats and men is that I have always noticed that when such operations are carried on in a seaway boats get unaccountably damaged, and have to lay up for repairs; and it has generally been my experience also that a certain number of men also needed repairs about that time. Now, with oil fuel the case is very different; the large tank steamers of the present day could always fuel the fleet, even in heavy weather. For instance, if I were going to fuel a man-of-war in bad weather, I should signal her to throw a rocket line aboard me, and haul a hawser aboard from her stern to my bows, in the usual manner described by the Board of Trade rocket apparatus. Having the hawser aboard and made fast, I should signal the war ship "steam ahead slow", and then let her send aboard the tank on the hawser a line; to that I secure my hose, which the man-of-war can heave in, and when it is coupled up, I pump in the fuel at any rate I wish, according to size of hose and power of pump. The hose, of course, should be secured to the hawser by hanks, which would enable it to be kept straight, besides

being a great help in getting it aboard again. Common canvas hose will do, as *residuum* will not penetrate it, especially the seamless, double-ply woven hose.

* * * I believe the Admiralty are thinking of burning oil fuel, but have not as yet decided what kind to use. I should certainly say not crude oil, but *residuum*, for a hundred reasons, of which to-night I shall only state a few. (1) Its being so perfectly safe while on board ship. (2) It can be stored on shore so easily, and, in the event of a fueling port being bombarded, shells could not set fire to the tanks. (3) It can be handled, without risk of fire or explosion, from the shore to the ship, or *vice versa*, and it does not deteriorate by exposure to the weather.

An article of interest in this connection, on "Petroleum as the Future Fuel of the Pacific Coast", appears in *Engineering*, May 22, 1891, in which it is stated that both the Oroya Railroad and the Molliendo, Arequipa, and Puno Railroad, of Peru, have decided to use fuel-oil instead of coal. Careful comparative experiments with oil and coal, extending over a period of six months, have led to the adoption of this step, and the Oroya road already has a number of engines running with the new fuel, whilst the other road has begun the necessary alterations to its locomotives. The fuel-oil used is petroleum refuse, or *residuum*, having a fire test of about 300° F., and is the same fuel referred to in Captain Carmichael's paper.

Two locomotives, one using coal and the other using fuel-oil, were run in competition on the Oroya Railroad for five months, from April 30, 1890, to the beginning of September, pulling equal trains alternately over the same ground. The locomotives—American Rogers, Mogul type—were exactly alike except in their furnace arrangements. The grades of the Oroya road are unusually heavy, and it is stated with regard to the performance of the oil-burning locomotive that the steam-gauge recorded from 135 to 140 pounds, never falling below 135 and very rarely rising above 140; as a rule the hand of the gauge stood immovable at 140 pounds; the safety valve was set at 142 pounds; on all the grades up to 3 per cent., no smoke whatever was discharged; on the 4 per cent. grades, a light hazy smoke was visible at times. The average consumption of fuel-oil per train-mile was 38.55 pounds, as compared with an average consumption of coal of 79.3 pounds per train-mile in the other locomotive.

Cuts of the installation adopted accompany the article in *Engineering*. It is reported as possessing the advantages of cheapness, simplicity, and endurance. A modification of the same system is adapted for use in marine boilers, and has been applied with much success on board the London and Pacific Company's steamship *Ewo*, already referred to in Captain Carmichael's paper. It is stated that no smoke is ever seen to issue from the smoke-pipe of the *Ewo*, and that her performance has shown an improvement from a speed of 8½ knots on 7 tons of coal per day to a speed of 9 knots on less than 4 tons of fuel-oil per day.

The Peruvian Government has directed the London and Pacific Petroleum Company to alter the gunboat *Santa Rosa* for burning oil. The South American Steamship Company of Valparaiso have also notified the Company of their intention to send up the steamship *Limari* for similar alterations.

ITALIAN EXPERIMENTS.

Brief notices have appeared in various engineering and service papers from time to time during the past year regarding experiments in the use of liquid fuel by the Italian naval authorities, from which, whilst no definite information is afforded as to technical details, it would appear that satisfactory results have been obtained. The following paragraphs may be quoted with reference to this subject:

> Some experiments have been made with a mixed fuel of coal and petroleum on the Italian man-of-war *Messaggiero*. The vessel, which never before surpassed 15 knots per hour, reached almost 17 with the new combustible. The engineers complained, however, that the high heat generated injured the boilers.
>
> *Engineering*, *June* 6, 1890.

> We learn from the *Esercito Italiano* that successful trials have been made at Spezia, on board the *Castelfidardo* and *Ancona*, of the system of Captain Cuniberti for applying petroleum as a combustible to marine boilers. * * * So satisfactory do the Italian trials seem to have been that, as we learn, a course of instruction in the necessary procedure for the application of liquid fuel is about to be commenced on board the *Ancona*.
>
> *Army and Navy Gazette*, *January* 31, 1891.

> The Italian Minister of Marine has received the reports relative to the experiments made at Spezia in the use of petroleum as fuel on board vessels of war. These reports being favorable, it is thought that petroleum will be gradually adopted in vessels of the Italian fleet. * * * The Minister of Marine is in accord with his colleague of Industry in seeking means to establish petroleum refineries in Italy.
>
> *Annales Industrielles*, *February* 8, 1891.

The last paragraph would indicate that the petroleum fuel referred to is not petroleum in the crude state, but probably the *residuum* or refuse after refining, the same fuel already referred to in the extracts from Captain Carmichael's paper, and which has been used with such success on Peruvian railways and coast steamers.

PROPULSION.

THE MARQUE PROPELLER.

This propeller, the invention of A. Marque, of Brussels, is described as follows in *Le Yacht*, December 13, 1890:

> This new propeller, called the Marque propeller, consists essentially of adjustable blades having their bases seated in a spherical hub fixed to the propeller shaft; by means of a system of racks moved at will by a lever on deck and gearing with pinions attached to the bases of the blades, the latter take any desired angular position relatively to the axis of the shaft, corresponding to a greater or lesser pitch. The lever is advantageously replaced by a small motor, the operation of which is under the immediate control of the officer who manœuvres the vessel.

It may be seen that this device permits the speed of a vessel to which it is applied to be regulated entirely from the bridge without signaling to the engine-room, simply by changing the pitch. This may be reduced to zero and reversed, thus reversing the driving action of the propeller without reversing the engines. The blades of the propeller are flat.

Accounts of the very successful trials of this propeller as applied to the French yacht *Avenir* are given in *Le Yacht*, December 27, 1890, and, with illustrations, in *The Marine Engineer*, April, 1891. From these articles it appears that the tests were directed to investigate two distinct points, namely, the mechanical efficiency of the propeller, and its effect upon the handling of the vessel. To compare the efficiency with that of the ordinary screw, a series of trials were made, first with the one and then with the other, under the same conditions as to steam pressure and speed of the engines. A preliminary series had to be made to determine the proper angle for the blades of the Marque propeller in order to satisfy the required conditions as to revolutions and steam pressure and at the same time to realize as high speed as possible for the vessel. The screw with which the Marque propeller was compared was considered of good design; its slip was 22 per cent. The result of the comparative tests gave the efficiency of the Marque propeller practically the same as that of the screw. The exact figures are not published.

In its effect upon the handling of the vessel, the trials demonstrated that the new propeller could be depended upon for most satisfactory results. It was found as the average of a great number of tests that the interval elapsing between the time of issue of the command to stop and the time of complete loss of headway by the vessel was reduced 75 per cent. From running at full speed, dead stoppage of the ship was effected in 29½ seconds. The published reports give no information concerning the governing apparatus of the engines, nor of the variations of speed of the engines caused by the variations and reversals of the pitch of the propeller in the trials. It is stated, however, that reversal of the blades was not attended by any bad effect upon the working of the engines, and further, that after a series of constant changes in the angles of the blades at all speeds throughout the trials, which extended to 645 hours in total duration, a minute inspection failed to reveal any strain, wear, or bending of parts in the mechanism.

It is reported (*Rivista Marittima*, February, 1891; *Marine Engineer*, April, 1891) that on account of the promising results of these trials, and of the equally satisfactory performance of this system as applied to the yacht *Berthe*, it has been decided by the French Ministry of Marine to try the Marque propeller on the small gunboat *Laborieux*, of 800 H. P., at Brest.

W. H. ALLDERDICE,
Asst. Engr., U. S. N.

III.

NOTES ON ORDNANCE.

In the record of progress in ordnance during the past year will be found references to the following notable events:

The failure of another English 110-ton gun.

The successful results of an unusually severe proof trial of a Canet 12.6-inch, 65-ton, breech-loading rifle constructed for the Japanese navy.

Gruson's Tangerhüette experiments, in which the tests of rapid-fire guns were the most complete ever undertaken, and the results obtained most valuable. The trials of a rapid-fire gun against a target representing the forward part of a torpedo boat, and of a rapid-fire howitzer against earthworks, were especially noticeable.

Krupp's protective deck experiments with armor-piercing projectiles discharged from breech-loading rifled howitzers at long range.

Important trials of rapid-fire guns.

The development of a new model of the English magazine rifle.

Practical tests of cellulose.

Late practical developments in torpedo warfare.

The notes on armor and high explosives will be found in the articles on those subjects in succeeding chapters.

Up to the present time a 9.2-inch breech-loading rifle has attained an actual range of 12⅓ miles, which was within a few hundred yards of the calculated range. The calculated maximum ranges of modern high power guns of larger calibres are even greater.

The maximum ranges of the armor-piercing calibres of rapid-fire guns are not less than 9 miles.

With the pneumatic gun a range of 2.4 miles has been attained with dummy projectiles.

HIGH-POWER GUNS.

The day of monster guns for use on shipboard seems to have passed. The largest guns now known to be in course of construction are of 13½-inch calibre, weighing 67 tons.

In the use of smokeless powders, the chamber pressure may be no greater than is obtained from good brown and black powders, but it decreases so gradually as to bring an increased strain on a part of the bore which has heretofore never been intended to bear it, in consequence of which the new guns designed to use smokeless powders have been given an additional thickness in the chase and are of a greater total weight.

CHILI.

Some of the Chilian vessels, notably the *Capitan Prat*, are to have Canet 24 cm. (9.45-inch), 40 calibre, 31 ton breech-loading rifles in their main batteries, which were constructed to use smokeless powders.

These guns, which are to be supplied with ammunition and to be worked and sighted by electricity, are to impart a muzzle velocity of not less than 2,400 f. s. to a 374 pounds projectile.

The Fiske Range Finder is mounted on the *Capitan Prat*, to be used in connection with these guns.

CHINA.

The Government factory at Kiangnan is now engaged in turning out all steel breech-loading rifles up to 12-inch calibre and of 35 calibres length. Two types of guns are made, one of all steel, the other with tubes of steel and jackets and hoops of iron. All the steel used is imported from England rough turned.

ENGLAND.

During the year ending December 31, 1890, the following breech-loading guns were constructed for the English navy:

Calibre.	Weight.	Number constructed.
	Tons.	
16.25-inch, high-power	110½	2
13.5-inch, high-power	67	11
10.0-inch, high-power	29	2
9.2-inch, high-power	22	12
6.0-inch, high-power	5	12
	Cwt.	
5.0-inch, high-power	40	41
4.0-inch, high-power	26	24
6.0-inch, rapid-fire	....	2
4.72-inch, rapid-fire	....	134

On the above date the number of breech-loading guns afloat and mounted in the English navy, exclusive of rapid-fire and machine guns, was 1,410.

Orders have been issued from the Admiralty that all naval guns up to 10-inch calibre inclusive shall be fitted for man-handling; not to the exclusion of hydraulic or other power for loading and pointing, if such

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PLATE I.

ARMSTRONG 16.25-INCH, 110½-TON GUN

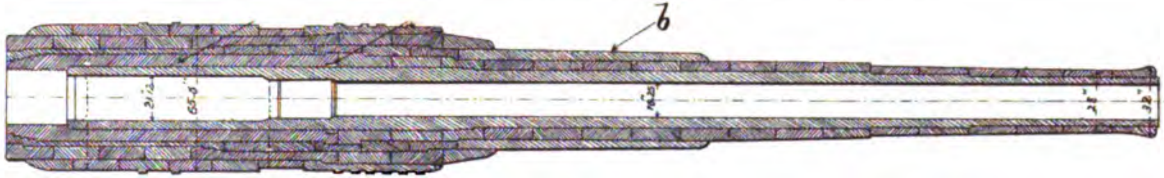


FIG. 3, MOUNTED ON H. M. S. VICTORIA

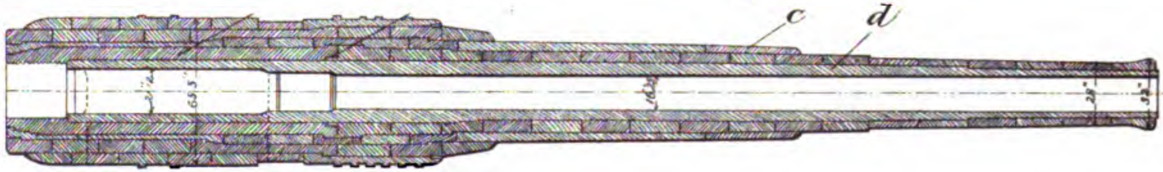


FIG. 2, MOUNTED ON H. M. S. SANSPAREIL

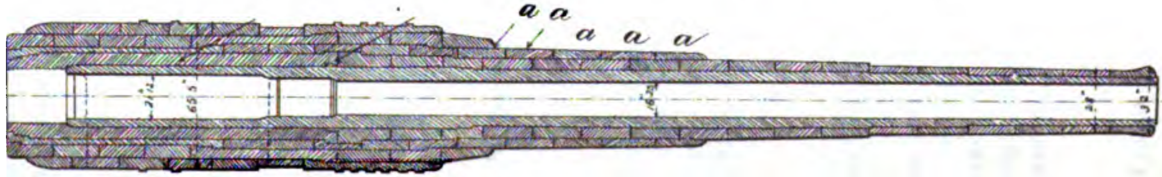


FIG. 1, MOUNTED ON H. M. S. BENBOW

power can be applied to advantage, but simply to have hand power readily available as a reserve in case the other power is put out of action. The *Thunderer's* two 38-ton turret guns have been replaced by two 10-inch, 29-ton breech-loading rifles fitted to be trained in elevation and loaded by hand, and to be trained in direction by revolving the turret by steam power. The removal of hydraulic machinery from this vessel made a saving in weight of more than 40 tons. The guns of several other English vessels are to be fitted in a similar manner.

A number of gun casualties have occurred during the past year.

An 8-inch B. L. R. of 25½ calibres length of bore, in target practice at Singapore, exploded at the first round, the chase being blown into many pieces.* This gun was originally constructed at Elswick for China, but was afterwards purchased by the English Government.

A 6-inch B. L. R. exploded on the *Cordelia*, during target practice on June 29th, 1891, killing three officers and three men, and wounding seven men. No details have yet been received.

Defects have been found in the fitting of the liners to large guns. Two of the 67-ton guns of the *Howe* had to be replaced by others on this account, the enormous friction produced by their projectiles in passing through the bores having resulted in turning the liners.

One of the *Camperdown's* 67-ton guns had to be replaced on account of the splitting of its liner.

In the English naval manœuvres of last year one of the *Hero's* 45-ton guns was put out of action for several hours by reason of an accident to its hydraulic gear.

Two of the 80-ton guns of the *Inflexible* were put out of action through accidents to the recoil checks of their mounts. As the proper repairs could not be made on board ship it was found necessary to send the vessel into port.

Altogether the English do not seem to get along very well with their big guns.

The question of relining may prove a serious one in war time. It is not known how many rounds can be fired from the various large calibres before it will become necessary to reline; nor even that a vessel would be able to fire her allowance of ammunition before such a necessity would arise.

FAILURE OF THE SANSPAREIL'S 110-TON GUN.

The 110-ton gun as originally designed is shown in Fig. 1, Plate I, but after the accident to the *Victoria's* gun described on page 77, No. IX, that and the remaining unfinished guns were strengthened by removing the five front hoops of the second layer, *a*, Fig. 1, and replacing them by a single long hoop as shown at *b*, Fig. 3. In the *Sanspareil's* gun an additional hoop, 3¾ feet long and weighing about 1¼ tons, was shrunk on forward of this, as at *c*, Fig. 2. This gun is stated to have had but a partial proof trial—6 shots only—at Woolwich, due to haste in preparing the *Sanspareil* for sea. In December, 1890, the ship trial took place at sea, and at the second shot, reduced charges only having been used, the strengthening hoop *c*, Fig. 2, split longitudinally along its left side, and was also a little displaced. When this split hoop was removed it was discovered that the hoops of the first layer underneath it were so separated from each other that the tube *d*, Fig. 2, could be distinctly seen through the open spaces. A slight extension of the bore was also apparent.

The gun was removed from the ship, and, after the split hoop had been replaced by a new one, was subjected to a trial of 6 rounds with full charges, after which it was found that the muzzle had drooped a little downward and to the right, causing such a separating of the forward hoops that a knife blade could be inserted between them. Shortly afterwards, in February, 1891, one shot was fired from this gun at a target under the following conditions:

Details of target.—A Brown compound plate 7 feet square and 20 inches thick, at the back of which was a wrought-iron plate 8 inches thick, and all backed by 20 feet thickness of oak beams and 25 feet thickness of granite, concrete blocks, and brick masonry. A section is shown in the accompanying cut.

Firing details.—Weight of charge of S. B. C. powder, 960 pounds; weight of Holtzer a. p. projectile, 1,813 pounds; muzzle velocity, 2,093 foot seconds. Range, 500 feet.

The gun was sighted by means of tompions fitted with cross wires, and but one shot was fired. The projectile struck the ground short and to the right, and ricocheting over the target went out to sea. It is reasonable to suppose that the failure to hit the target was due to the fact that sufficient allowance was not made in sighting for the curved drooping of the chase.

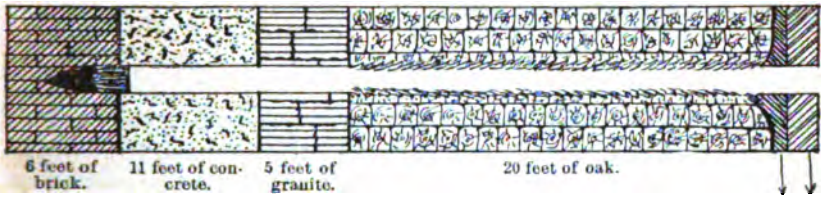
During the month following another shot was fired under the same conditions, except that a striking velocity of 2079 foot seconds, corresponding to a striking energy of 54,320 foot tons, was used.

The projectile struck the centre of the face of the plate and perforated the compound plate, the wrought iron plate, the 20 feet of oak backing, 5 feet of granite, and 11 feet of concrete, and finally came to rest after penetrating 6 feet into the brick masonry, as graphically illustrated in the accompanying cut.

A slight additional drooping of the muzzle of the gun took place. The gun was afterwards condemned, and another, after a reported successful proof trial, was mounted on board the *Sanspareil* to replace it.

The failure of this gun only accentuates the belief expressed on page 77, No. IX, that all the English guns of this calibre are unreliable. Up to the present time this one gun has only fired 16 rounds, and not all of that number with full charges. Its chase now droops so much and some of its parts are separated to such an extent as to render it practically useless.

In only one way can any satisfactory conclusion be reached in regard to these 110-ton guns, and that is by trying one of them to destruction with full charges. We can not believe that this would be a particularly expensive operation with either of the *Sanspareil's* guns as first mounted if, as we understand, the remaining gun is that one, originally intended for the *Victoria*, which failed last year; for it does not seem reasonable to suppose that either one of them could stand many more rounds with full charges before reaching a condition in which it would be actually dangerous to try them further.



FRANCE.

The French had serious trouble with their large navy guns several years ago, one of the largest, a 16.54-inch B. L. R., having yielded at the muzzle. They soon after discarded the design. Of late the principal French publications have intimated very plainly that all French navy guns of over 12.6-inch calibre are far from satisfactory.

The Fiske Range Finder has been tested by the French naval authorities with marked success.

GERMANY.

In the German navy the largest gun afloat is the 12.01-inch Krupp B. L. R., and no larger calibres have yet been designed.

ITALY.

The two Krupp 119-ton guns lately mounted on the coast defense essels *Castor* and *Pollux* have been removed from these vessels and nounted on shore for coast defense.

In the navy there are eight 100-ton muzzle-loaders mounted on the *uilio* and *Dandolo*, and twenty 105-ton breech-loaders mounted in sets four each on the *Italia*, *Lepanto*, *Doria*, *Lauria*, and *Morosini*. Of ese guns the bursting of a 100-ton muzzle-loader on the *Dandolo* is too well known to need comment. No reports of serious accidents to the others have ever been received, and it is generally understood that Italian naval officers find no fault with them.

The Fiske Range Finder has been tested by the Italian naval authorities and gave excellent results.

JAPAN.

Of the Canet 12.6-inch, 40 calibre, 65-ton breech-loading rifles ordered for the latest Japanese coast defense vessels—*Matsushima*, *Itsukushima*, and *Hashidate*—one was tried in France this year by a commission composed of French officials and representatives of the Japanese Government.

In the contract it was stipulated that 20 rounds should be fired with progressive charges, and that if the gun should show any signs of weakness at the end of the fifteenth shot, the number of rounds should, if found possible, be increased to 60.

The following are the principal details of this most interesting trial:

No. of round.	Kind of powder used.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Chamber pressure (tons to square inch).
		Pounds.	*Pounds.*	*f. s.*	
1	PB_1S	264.4	762.9	1,660	4.25
2	do	307.5	762.9	1,794	5.64
3	do	353.0	767.3	1,965	8.75
4	do	350.6	761.8	1,955	8.95
5	do	351 6	987.8	1,791	9.52
6	do	396.2	987.8	1,886	9.90
7	do	439.5	987.8	2,011	13.26
8	do	462.4	996.7	2,083	14.00
9	do	494.4	1003.3	2,149	14.55
10	do	529.2	985.6	2,227	16.25
11	BN_1 (smokeless)	220.5	771.8	1,701	4.81
12	do	242.5	995.6	1,814	7.75
13	do	264.6	985.6	1,944	8.94
14	do	286.7	996.7	2,158	12.45
15	do	297.7	995.6	2,302	15.19
16	do	304.3	988.9	2,286	13.59
17	PB_1S	540.2	1034.1	2,262	15.49
18	do	562.3	988.9	2,308	16.69
19	BN_1 (smokeless)	238.1	989.9	2,073	10.51
20	PB_1S	529.9	993.4	2,217	15.17

The BN_1 and BN. were samples from different lots of smokeless powder. At the end of the trial the gun showed not the slightest sign of weakness and was at once accepted. It is reported that, except at the eighteenth shot, the breech mechanism was easily manipulated by one man. It required not more than 20 seconds to open the breech after each shot.

In addition, it may be well to remark that after the firing, the Canet barbette carriage upon which the gun was mounted during the entire trial, and which will be described hereafter, was carefully examined and found to have undergone no injury from the heavy strains to which it had been subjected.

The charges of BN_1 were increased progressively from the eleventh to the sixteenth rounds, giving increased velocities and pressures up to the fifteenth round, inclusive. But at the sixteenth round the entire charge of powder was not completely consumed in the bore, which accounts for the reduced velocity.

During the last month, the ship trials of this gun have taken place. Five shots were fired with excellent results.

ARMOR-PIERCING (a. p.) PROJECTILES.

Those manufactured by the Holtzer and Firminy processes are still considered unequaled, the former being employed by England, France, and Russia, and the latter by France, England, Spain, and the United States.

The results of trials of these projectiles referred to on page 95, No. IX, and their excellent performances at the Annapolis and Ochta armor trials were all obtained with high striking velocities, and it is not improbable that to this fact, as well as to the good quality, toughness, and temper of the projectiles is due such remarkable results.

Up to the present time all interest has centered in these sharp-pointed projectiles, with which the only object sought has been penetration on normal impact, but little attention having been given to the effects of blows delivered at sharp angles. The most important tests of such effects were carried out several years ago at the naval ordnance proving grounds with projectiles having differently shaped heads, but as yet the results have apparently been put to no practical use.

The decided results obtained at late armor trials, however, have caused some little discussion as to the practicability of using flatter headed projectiles for oblique attack of armour, and it is possible that it will result in causing experimental investigations which may prove of practical value.

Such is the perfection to which a. p. projectiles have attained, as applied to the attack of the systems of armor now found afloat, that their use is becoming general, and we are no longer able to judge of the value of armor for protection from its attack by any other kind of projectile.

At the present time the Holtzer and Firminy have so improved in quality, toughness, and temper as to be able to attack compound and steel plates without being cracked and with but little liability to deformation.

But this year they have been subjected to a trial which they could not withstand, the severest trial to which any projectiles have ever been subjected. In March, three Holtzer 6-inch and three Carpenter 6-inch a. p. projectiles were fired at a 10½-inch Schneider steel plate treated by the Harvey process, and were completely destroyed. No better illustration of the effect on these projectiles can be given than that which will be found in the description of this trial detailed in the chapter on "The Armor Question in 1891."

RAPID-FIRE GUNS.

The successful use of guns of this system up to a calibre of 6 inches is now an assured fact, and their functions on board ship are so important that it is recognized that a superiority in their fire will be one of the most important elements of success in future naval actions. Their qualities will be fully brought into play when there is no delay between fires beyond that actually necessary for aiming.

The degree of rapidity of fire possible with this system is now sufficiently great to satisfy the most exacting artillerist, but this rapidity can only be obtained when the supply of ammunition is rapid and continuous, and the propellant used does not give off sufficient smoke to obscure the target. These two factors are absolutely essential to a maximum rapidity of fire.

In the armor-piercing calibres of rapid-fire guns, such as those of Canet and Armstrong, the high velocities obtained with smokeless powder charges give such flat trajectories that point-blank aiming is possible up to very long ranges; a decided advantage in opposing torpedo-boat attacks, as the more direct and more rapid the gun fire the greater the possibility of hitting.

Two new types of rapid-fire breech mechanisms have been accepted for experimental tests during the past year.

One, to be tried in an army 5-inch siege rifle, is the invention of Lieutenant S. Seabury, U. S. Navy. It is on the interrupted screw system; all the movements necessary to unlock the breech plug, to withdraw it into its tray, to swing all clear of the line of the bore, to loosen and extract the empty cartridge case, and to set the firing pin for the next discharge, are effected in one motion by moving a crank arm through an angle of 274 degrees. A special device permits the use of either fixed or ordinary ammunition at will.

Another type, which is now ready to be tried in the new Navy 5-inch rapid-fire guns, is the invention of Ensign R. B. Dashiell, U. S. Navy. It is also on the interrupted screw system, and can be applied to any gun, the breech plug of which is operated by manual power. All the operating mechanism is carried on the plug supporting tray except the trigger, which is on the gun. The breech is opened or closed by a single curvilinear movement of a lever arm.

ARMSTRONG RAPID-FIRE GUNS.

The 4.72-inch and 6-inch guns of this type have undergone frequent successful trials in England. Of the former calibre 134 guns were constructed for the English navy during the year ending December 31, 1890.

A 6-inch, 40 calibre, trial gun, weighing 6 tons 13 hundredweight, attained a rapidity of five aimed shots in 55 seconds, four of them striking a target—two casks lashed together—at a range of 900 yards. The following are fair samples of results obtained in firing trials:

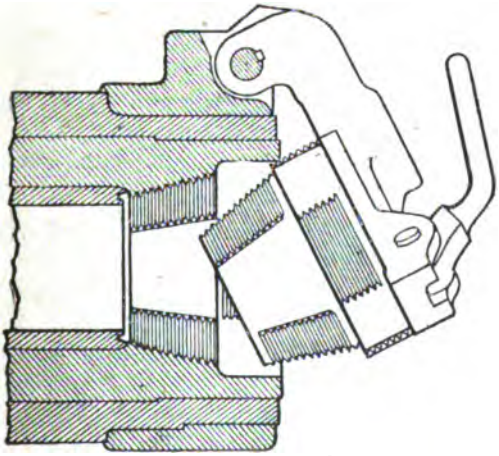
Rapid-fire gun used.	Powder used.	Charge.	Projectile.	Muzzle velocity.	Chamber pressure (tons per square inch)
		Pounds.	*Pounds.*	*f. s.*	
4.72-inch	Cordite	5.6	45	2,196	14.0
6.00-inch	Cordite	17.0	100	2,413	14.7

With cordite of .35 inch diameter a muzzle velocity of 2,380 f. s. was obtained with a corresponding chamber pressure of 13.4 tons per square inch, and with cordite of .3 inch diameter a muzzle velocity of 2,669 f. s. with corresponding chamber pressure of 20 tons per square inch.

The extra weight of the 6-inch gun over that reported in No. IX has been found necessary in order to allow the thickness of walls of bore to conform to the more continuous high pressures of smokeless powders.

It is understood that the service muzzle velocity of this calibre will be 2,500 f. s.

The accompanying cut illustrates the breech closure used in this type of rapid-fire guns.



The breech block is, as shown, in two coned steps, each containing three sets of screw threads and three sets of blanks, the threads in one step corresponding to the blanks in the other. When swung laterally into place in the breach of the gun a rotary movement of 30 degrees will cause these screw threads to take in corresponding screw threads cut in the interior wall of the breech. Either electric or percussion primers can be used, but it is intended to use the former in service.

Firing by electricity and without aiming, the 4.72 inch has been discharged twelve times in 65 seconds.

To give an idea of the rapidity of fire possible with these guns on board ship we append the results of a trial of an Armstrong 6-inch rapid-fire gun mounted in the bows of the gunboat *Kite* in such a manner as to represent a between-decks gun.

With a crew of 5 men and using a 100 pound projectile, and a separate charge of 34 pounds of E X E powder, the gun was fired electrically, in series of ten rounds each, in times as follows:

No. of rounds.		Elevation.		Time of firing.		Remarks.
		deg.	*min.*	*m.*	*s.*	
1 to	10	5	0	1	30	These were not fired for rapidity.
11	20	10	0	2	58	Considerable delay, owing to vessels getting into range.
21	30	15	0	2	3	
31	40	15	0	1	54	
41	50	about horizontal.		1	40	
51	60	do.		1	31	Fired against time.
61	70	1	5	1	28	Aimed at a fixed target 1,500 yards distant.
71	80	about 1°..		2	14.4	Aimed at a fixed target from 1,200 to 1,500 yards distant.
81	90	about 2°..		2	29	Aimed at two targets. The gun trained on each alternately.
91	100	1	50	2	4	Aimed at two targets. The gun trained on each alternately.

The English have lately been experimenting with a rapid-fire howitzer.

The only calibres of the Armstrong rapid-fire guns constructed up to date are of 6-inch, 4.72-inch, and 2.75-inch.

The last is a 10-pounder, which, in trials at Silloth, England, attained a rate of five unaimed rounds in 24 seconds.

The use of fixed ammunition for the 6-inch and 4.72-inch has been definitely abandoned in the English service.

CANET RAPID-FIRE GUNS.

In addition to the guns of this type described on page 102, No. IX, the following calibres have been designed and will be constructed at the Forges et Chantiers de la Mediterranée; three guns of different lengths to be constructed of each calibre with details as in the following table:

Calibre in inches.	Total weight in pounds.	Total length in calibres.	Length of bore in calibres.	Rifling.		Smokeless powder charge.	Projectile.	Estimated initial velocity.	Estimated maximum range.
				Inclination.	Number.				
						Lbs.	*Lbs.*	*f. s.*	*Yds.*
2.56	661	30	28.1	Uniform at angle of 6°.	20	1.2	8.8	1,640	11,171
	882	40	38.1		20	2.3	8.8	2,165	13,681
	1,102	50	48.1		20	3.3	8.8	2,559	14,953
2.95	1,036	30	26.1		22	1.8	13.2	1,640	11,384
	1,367	40	38.1		22	3.3	18.2	2,165	13,971
	1,676	50	48.1		22	4.9	13.2	2,559	15,310
3.54	1,764	30	28.1		28	2.9	22.0	1,640	11,429
	2,359	40	38.1		28	5.3	22.0	2,165	14,054
	2,910	50	48.1		28	7.9	22.0	2,559	15,410
5.51	6,724	30	28.0		42	7.7	70.6	1,640	11,735
	8,907	40	38.0		42	15.9	70.6	2,165	14,495
	11,023	50	48.0		42	24.7	70.6	2,559	15,946

The further trials of the Canet 15-centimetre (5.91-inch) R. F. gun referred to on page 106, No. IX, gave results as follows:

Kind of powder used.	Weight of charge.	Weight of projectile.	Initial velocity.	Chamber pressures (tons per sq. inch).	Muzzle energy.	Energy.	
						Per ton of gun.	Per pound of powder.
	Lbs.	*Lbs.*	*f. s.*		*f. t.*		
BN, smokeless, sample B..	17.64	88.2	1,811	6.6	2,005	331	114
Do....................	25.35	88.2	2,467	16.0	3,721	615	147
Do....................	26.46	88.2	2,605	19.8	4,149	686	157
BN, smokeless, sample A..	31.97	88.2	2,775	18.3	4,708	778	147
Do....................	33.08	88.2	2,880	20.8	5,071	838	153

The ammunition for the 4.72-inch gun is fixed, but that for the 5.91-inch gun is separate, the projectile and the metallic case containing the charge being connected by a bayonet clutch arrangement just before insertion in the bore of the gun.

These two calibres are to be fitted with automatic sights, so arranged that when the rear sight is set to the desired degree of elevation the gun will assume the same angle, thus adding to the rapidity of fire.

M. Canet has invented an illuminated sight for use with his rapid-fire and high-power guns at night, which is very similar to the English service night sight described on page 97, No. IX, the principal point of difference being in the rear sight, from which two rays of red light are reflected instead of the one ray of the English sight.

The line of sight is obtained by bringing the ray from the front sight between the two of the rear sight. The rays are red and white in color, and, by means of suitable resistances, can be varied in intensity at will. The batteries used to feed the lamps will furnish the necessary current for from 8 to 10 hours.

At the Hoc Polygon some very interesting trials were carried on this year with the Canet rapid-fire guns. Details of some of these will be found in the following tables.

Trials of Canet 12-*centimetre* (4.72-*inch*) *R. F. gun.*

Date.	Powder used.	Charge.	Projectile.	Muzzle velocity.	Chamber pressure (tons per square inch).	Remarks.
		Lbs.	*Lbs.*	*f. s.*		
Feb. 26, 1891..	BN$_1$ (smokeless)..	11.0	46.9	2,329	14.3	In firing for rapidity, 5 unaimed shots were fired in 24 seconds with fixed ammunition.
Do.......	....do	12.1	46.9	2,486	17.3	
Do.......	....do	13.2	46.7	2,683	22.6	
Mar. 24, 1891 .	....do	12.1	46.8	2,434	16.1	
Apr. 4, 1891 ..	....do	12.1	46.8	2,486	16.2	

Trials of Canet 15-*centimetre* (5.91-*inch*) *R. F. gun.*

Date.	Powder used.	Charge.	Projectile.	Muzzle velocity.	Chamber pressures (tons per square inch).	Remarks.
		Lbs.	*Lbs.*	*f. s.*		
Feb. 26, 1891..	BN, (smokeless)..	25.35	89.4	2,532	19.2	
Mar. 24, 1891 .	....do	22.05	88.6	2,204	15.0	
Do.......	....do	24.25	88.8	2,390	17.3	
Apr., 1891....	....do	24.25	89.1	2,496	19.7	Seven unaimed shots fired in 54 seconds.

In the February trials all the cartridge cases had been used at least twice before, but the cases all proved good and there were no hang or miss fires. The highest pressure yet developed in this gun was 26.2 tons per square inch, and that without any apparent injury to the gun.

The Russian naval authorities have officially adopted this type of rapid-fire gun for naval use. This action was taken upon the report of a special commission after it had visited the Armstrong, Gruson, Krupp, and Canet works to witness exhaustive trials of their rapid-fire guns.

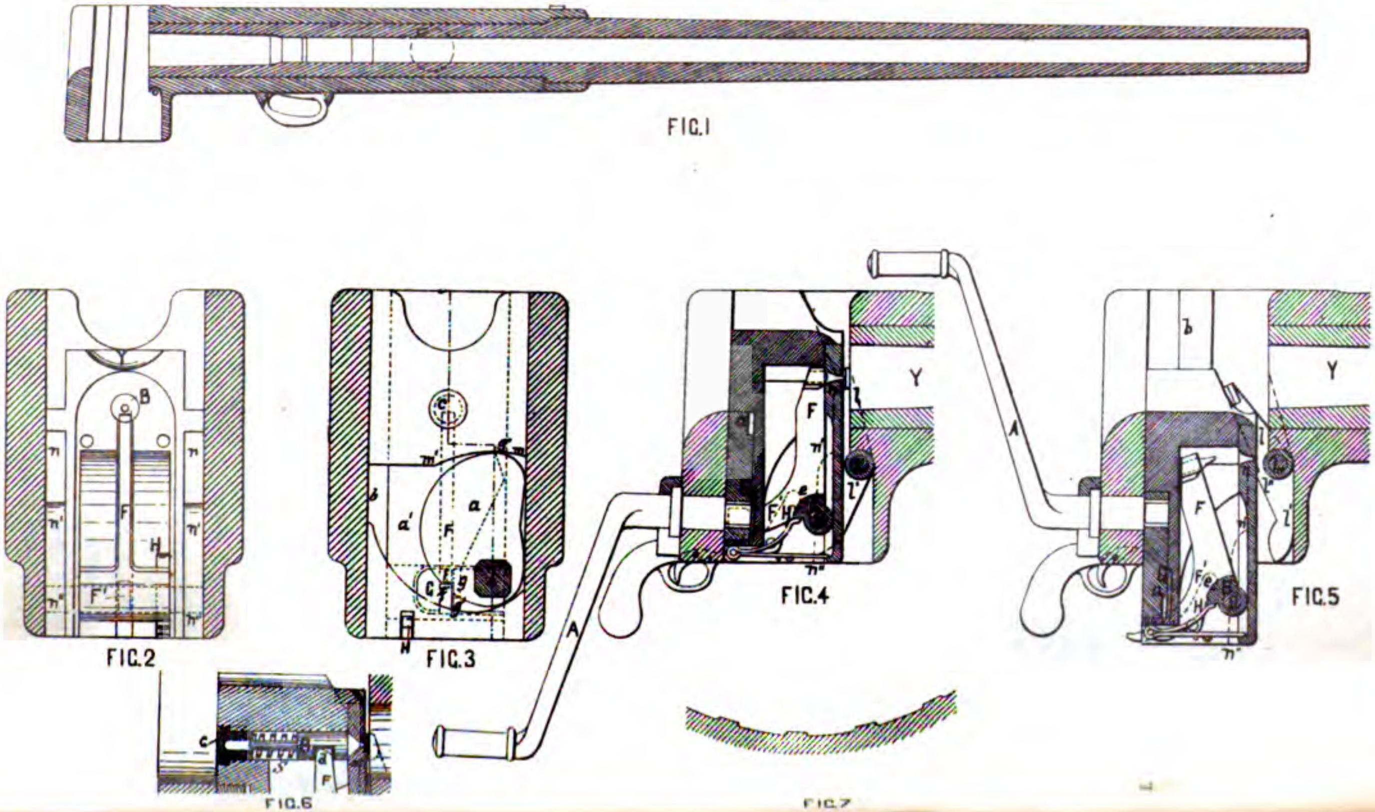
FINSPONG (THRONSEN) RAPID-FIRE GUN.

This gun, which was referred to on page 113, No. IX, is of the usual compound construction as shown in Fig. 1, Plate II, the tube, jacket, and breechblock being made of Finspong cast-steel, not forged.

Breechblock.—This is a slightly tapered, vertically falling block which is lowered and raised by means of the handle A, Figs. 4 and 5, of a shaft secured at its inner end to a cam, *a*, of the form shown in Fig 3, and working in a recess, *a'*, Fig. 3, in the rear face of the block. The upper surface of the block and also that of the breech piece of the gun are scored out as shown in Figs. 2 and 3, to permit the introduction of the

PLATE II.

FINSPONG (THRONSEN) R.F. GUN.



cartridge with the least fall of block. The block is guided in its vertical movements by projections *b*, Figs. 3 and 5, in the side walls of the breech piece of the gun which take in corresponding grooves in the side walls of the block. The crank A is weighted and so fitted in reference to the cam that its weight serves to hold the block up when the breech is closed.

Firing mechanism.—The firing pin B, Fig. 6, has a stout spring and at its rear part ends in a tail which works loosely in a hollow in the plug *c*, Figs. 3 and 6, screwed into the rear of the block, which, when unscrewed, permits the removal of the firing pin and spring. Near the head of the firing pin is a recess *d*, Fig. 6. On a transverse shaft D, Figs. 4 and 5, is mounted a tumbler E, having two hammer arms F, F′, the former engaging in the recess *d*, Fig. 6, in the firing pin, the latter extending to the rear under the cam and taking in a notch *f*, Fig. 3, when the bore of the gun is closed by the block, and also engaging in a deep notch in the lower edge of a transversely sliding plate G, Figs. 3, 4, and 5, mounted to work in guides in the breech block just facing the cam. This plate serves to prevent accidental discharge of the gun before the block closes the bore. From the rear face of this plate there projects a lug, *g*, Fig. 3, which, during the movement of the block, is taken against by a shoulder extending across the inner face of the cam and represented in Fig. 3, by the dotted lines g′, g″. In the tumbler E, Figs. 4 and 5, is cut a notch *e* to receive the nose of the sear H.

Extractors.—These are double, each having two arms, *l* and *l*′, Figs. 4 and 5, mounted on a transverse spindle, L, through the breech piece of the gun, these arms being fitted to take in recesses in the sides of the chamber of the gun. On the lower arms, *l*′, are formed shoulders, *l*″, Fig. 5, and these lower arms are fitted to project into two cam slots, *n n*′ and *n*′ *n*″, Figs. 2, 4, and 5, on each side of the front face of the breech block.

To load (*the gun having just been fired*).—Turn the handle to the right and upward and the cam *a*, Fig. 3, will commence a movement to the left and downward for the first 30 degrees of its motion, following the curve *m m*′, of the upper wall of its recess, and not depressing the block. During this movement the shoulder *f*, Fig. 3, of a notched part of the cam depresses the lower hammer arm F′, Figs. 3, 4, and 5, which causes the upper arm, F, to force back the firing pin against the pressure of its spring until the nose of the sear H, catches in the notch *e*, of the tumbler E, Figs. 4 and 5, thus cocking the piece.

As the cam continues its revolution it acts on the lower wall of its recess to depress the block which reaches the end of its downward travel when the cam has revolved 180 degrees. When the score in the upper surface of the block completely clears the base of the cartridge case the projecting upper edges of the lower cam slots, *n*′, Figs. 2, 4, and 5, begin to push forward the toes of the lower extractor arms, *l*′, which cause the empty cartridge case to start from the bore. When the shoulders *l*″, Fig. 5, on the extractor arms, meet the projecting upper edges of the upper cam slots, *n*, the upper extractor arms, *l*, are moved suddenly backward and the empty cartridge case thrown out.

The cartridge is then introduced, after which a reverse movement of the handle will raise the block. The firing pin will remain locked by the plate G, until the block is nearly up, when the shoulder on the cam represented in Fig. 3 by the dotted lines *g′*, *g″*, engages the plate G, and moves it to the right far enough to put its notch out of register with the hammer arm F′, and thus unlock it.

The following are the principal details of three calibres of this type:

Details.	47 mm.	57 mm.	75 mm.
Total weight of gun .... pounds..	551	702	822
Length of bore, including chamber .... calibres..	48	42.5	31.3
Total length of gun .... do....	51.9	45.6	34.4
Rifling:			
No. of grooves	20	24	20
Depth .... inch..	.012	.012	.004
Twist, one turn in .... calibres..	173–25	180–30	87.7–33
Weight of charge; black powder .... pounds..	1.54	1.94	2.42
Weight of projectile .... do....	3.3	6.0	10.4
Muzzle velocity .... f. s..	2.027	1,863	1,443
Chamber pressure .... tons..	13.8	14.2	11.8

The Swedish Government has ordered a number of guns of this type. An experimental 75-millimetre gun has been constructed for Denmark, but with the arm which actuates the cam turned 90 degrees so as to bring the handle out at the right side of the breech of the gun.

GERICKE RAPID-FIRE GUN.

A system of breech-closure, known by the name of its inventor, Captain Gericke, of the Netherlands navy, has been applied to 37-millimetre (1.46-inch) rapid-fire guns for use in the navy.

The following description will be understood by reference to Plate III.

Breech block.—The falling block A, Figs. 1 and 3, has vertical faces, in the side of the left one of which is a groove *s*, Fig. 2, into which projects a screw lug from the side wall of the breech piece, the function of which is to limit the vertical movement of the block. The upper part of the block and the rear wall of the breech piece are scored out in such a manner as to permit the introduction of the cartridge with the least fall of block. A face plate, B, Fig. 3, with its front upper edge rounded, is fitted to the front face of the block. The rear face is scored out through the middle to permit the insertion of the interior mechanism. This score is closed by a curved plate, G, Fig. 3, which is held in place by a clamp, H, Fig. 4. The front upper edge of the block is rounded off to facilitate pushing the cartridge home. The block is worked from the left side of the gun, by means of a lever C, Fig. 1, on the axial bolt D, which actuates the cam E.

PLATE III.

GERICKE R.F. GUN.

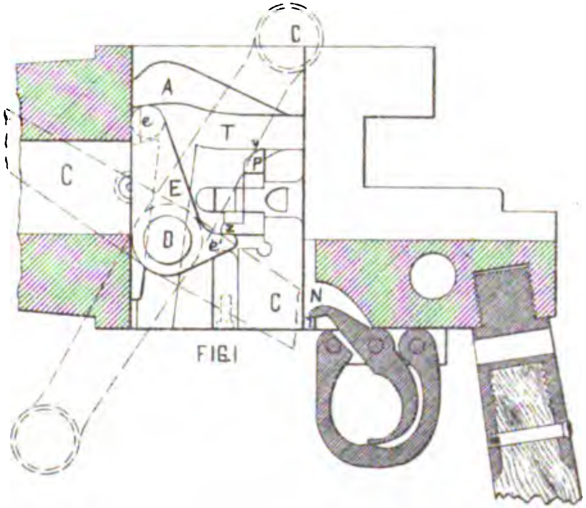


FIG. 1

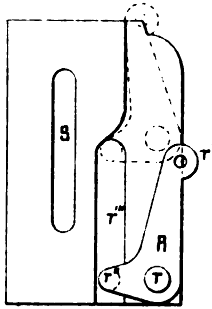


FIG. 2

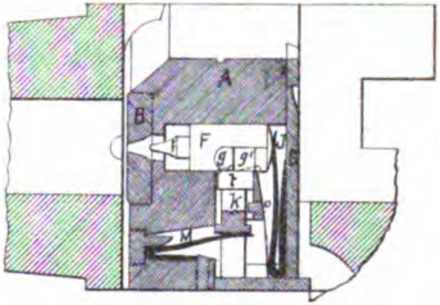


FIG. 3

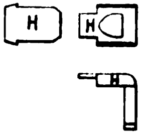


FIG. 4

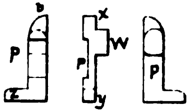


FIG. 5

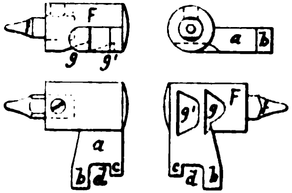


FIG. 6

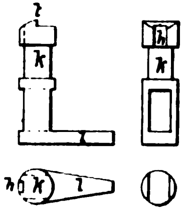
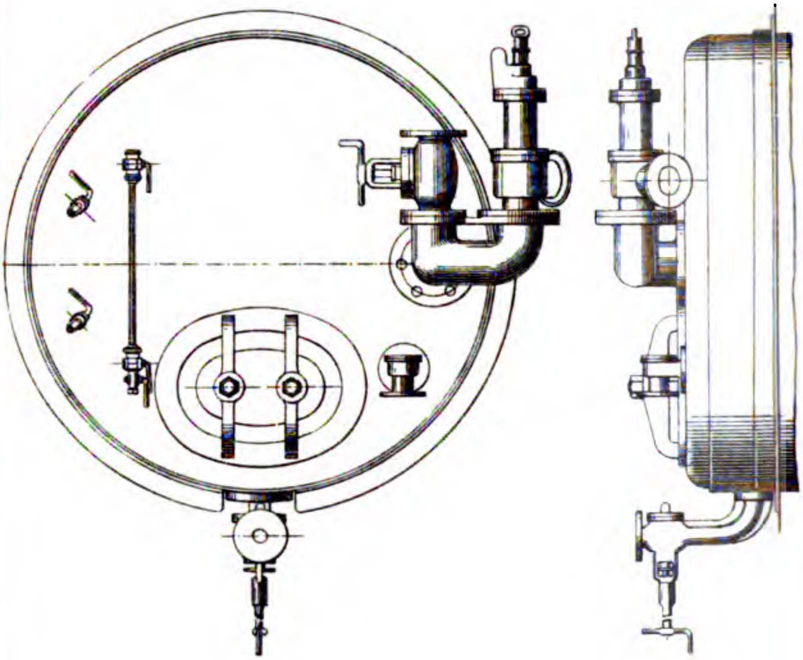
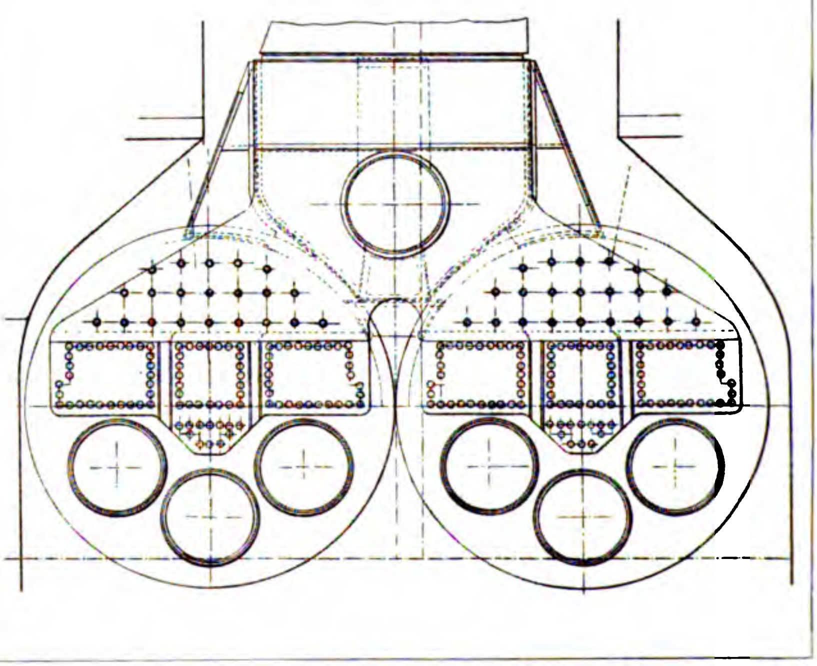


FIG. 7

PLATE IV.





Firing mechanism.—See Figs. 3 and 6. The firing pin consists of a cylinder, F, into which is screwed a striker, *f*. From the left side of this cylinder, Fig. 6, projects a plate, *a*, the end of which is in the form of two projecting lugs, *b* and *c*, one on each side of a slot, *d*. In the lower surface of the cylinder are two notches, *g*, *g'*. A two-armed firing spring, J, has its long arm pressing against the rear of the firing pin, and its short arm against the rear face plate G. The firing lock K, Figs. 3 and 7, is pressed up against the lower surface of the cylinder F by a two-armed spring, M, and is fitted to slide up and down in a groove, *h*, Fig. 7. At its lower extremity an arm, *l*, Fig. 7, projects at right angles with its point in contact with the trigger point N, Fig. 1. The amount of play of the lock is determined by the fixed screw O, Fig. 3. The safety pin P, Fig. 1, is of the form shown in Fig. 5, and is held in a recess within the breech block by the clamp, Fig. 4, of the rear face plate so as to allow the face X, Y, Fig. 5, to work in the slot *d*, Fig. 6.

Extractor.—A single two arm extractor, R, Fig. 2, is fitted on the right-hand side. It is pivoted to the face of the breech wall at *r*, the breech block being recessed in such a manner as to allow the extractor free play. The long arm has at its end a semi-circular extractor, *r'*, which fits into a recess cut in the bore and takes under the rim of the cartridge. At the end of the short arm is a stud *r''*, which works in a vertical slot, *r'''*, in the breech block, the slot having a little less length than the travel of the block.

To serve the gun.—Revolve the upper handle of the lever *c*, Fig. 1, to the rear, and the stud *e* of the cam E, Fig. 1, will travel to the rear along its guideway T. As soon as the upper arm of the cam passes the vertical, the block will commence to fall and will continue falling until it brings up on a stud fitting into the slot S, Fig. 2. In this movement the rear face of the cam takes against the projecting lug *b* of the firing pin, Fig. 6, and forces the firing pin to the rear against the pressure of its spring J, Fig. 3. As the firing pin is thus forced to the rear, the point *t* of the firing lock K, Fig. 3, takes successively in the notches *g*, *g'*, which respectively place the firing pin at half cock and at full cock, the latter position being maintained by the upward pressure of the spring M. As soon as the firing pin is at full cock the cam takes against the curved head V, Figs. 1 and 5, of the safety pin P, and forces it down, the lug W, Fig. 5, taking in the slot *d*, Fig. 6, of the firing pin and locking it securely. When the block has nearly finished its fall, the stud *r''* takes against the upper face of its slot, Fig. 2, causing the extractor *r'* to suddenly move to the rear on its pivot, *r*, and extract the empty cartridge case.

To load.—Enter the cartridge and push it well in. Reverse the lever and the block will commence to rise. When the toe *e'* of the cam, Fig. 1, takes under the projecting arm *z* of the safety pin, Figs. 1 and 5, the continued movement of the cam will gradually raise the safety pin until the bore is closed, when the lug W, Fig. 5, will become freed from the slot *d*, Fig. 6, and the firing pin will be unlocked. When the breech block is up a vertical spring, secured to its left lower face, and which has a swell on its upper end, will catch in a small cavity in the *e′* of the cam in such a manner as to lock the block in place. A smart rearward pull of the lever is required to release the toe of the cam from this spring.

To fire.—Pull the trigger and its point N, Fig. 1, will press on the arm *l* and draw the firing lock K, Fig. 3, down against the pressure of the spring M until the point *t* is freed from the notch *g*, when the firing pin will move violently forward under the action of the spring J, and explode the primer of the cartridge.

GRUSON RAPID-FIRE GUNS.

The most extended and complete trials of rapid-fire guns ever undertaken has been conducted by the manufacturer of the above-named type during the past year, and with results which proved conclusively the excellent character of the material tested.

Lack of space forbids mention of more than a few of the most important results obtained.

One of the most interesting experiments was with a rapid-fire howitzer which will be found described under the head of high-angle fire.

In one experiment a 3.2-inch, 35-calibre Gruson rapid-fire gun was tried with both black and smokeless powders, with results as follows:

Kind of powder.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Chamber pressure, per square inch.
	Pounds.	*Pounds.*	*f. s.*	*tons.*
Smokeless, c/89	2.25	15.4	2270	15.3
Black, c/86	5.51	15.4	2231	18.0

Twenty unaimed shots were fired from this gun in 49 seconds.

From a 2.24-inch, 25-calibre rapid-fire gun, 25 unaimed shot were fired in 30 seconds at a 1-foot square target set up at a range of 131 feet. The shots all struck the target and cut out a hole less than 4 inches across its greatest diameter.

From a 1.85-inch, 40-calibre rapid-fire gun, 9 unaimed shots were fired in 11 seconds and 16 unaimed shots in 26 seconds.

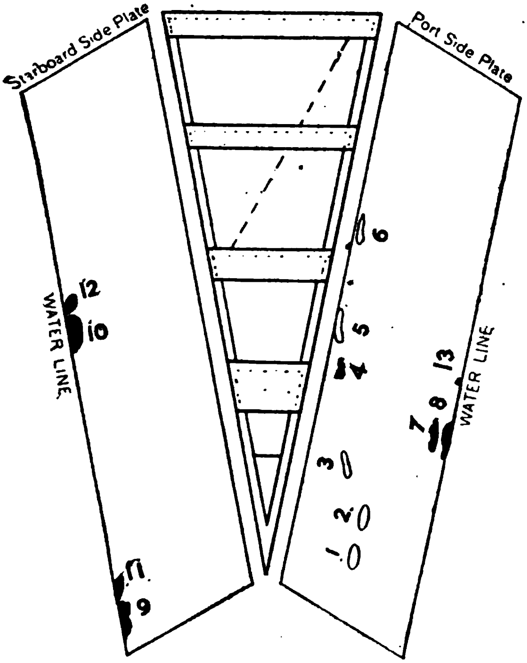
The rapidity and accuracy of this type of gun is exemplified by the interesting trial described below.

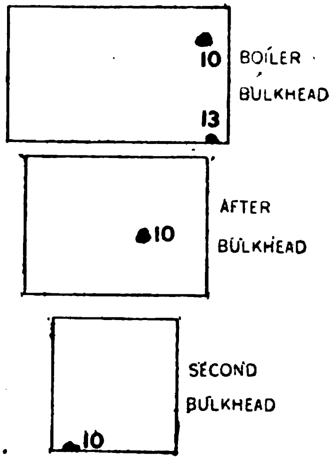
Firing trial at a target representing the bow of a first-class torpedo boat by a Gruson 53 millimetre, 39 calibre, rapid-fire gun.

DETAILS OF GUN.

Calibre	inches	2.09
Weight of breech mechanism	pounds	41.9
Total weight of gun	do	639.3

Total length of gun	calibres	39.1
Length of bore	do	35
Number of grooves in rifling		24
Weight of powder charge. Smokeless C/89	ounces	9.3
Weight of steel armor-piercing projectile	pounds	4.4
Muzzle velocity	f. s.	2,057
Striking velocity	do	1,752
Range	yards	547





The target consisted of two side plates and four athwartship plates. The side plates, which were 3.3 feet high by 15.6 feet long, were riveted to the bulkheads to form a wedge, the bulkheads being stiffened at their upper and lower edges by small angle irons, and having horizontal plates riveted along their upper edges to represent a deck. This structure was open at the bottom, and rested on wooden blocks in such a manner as to clear it from the ground by about 2½ inches.

[Material of target: Gruson's Bessemer steel.]

Thickness of side plates	inches	.315
Thickness of deck plates	do	.315
Thickness of boiler bulkhead	do	.472
Thickness of remaining bulkheads	do	.315

Firing details.—The plane of fire corresponded with the vertical longitudinal section of the boat. The gun was handled by men experienced in working rapid-fire guns, the range was accurately known, and gun and target were stationary; in consequence of which 13 shots were easily fired in 30 seconds. The effect of each shot is shown on the diagrams above.

For simplicity of explanation these are numbered, but these numbers do not represent the order in which the shots were fired, the rapidity of fire having been too great to note the results on the target until after the test was finished.

Nos. 1, 2, and 3 all struck about half way up the port side forward of the first bulkhead and within a foot of each other, bulging in and deeply scoring the plate, but not penetrating.

Nos. 4 and 5 struck high up on the port side between the first and second bulkheads, No. 4 penetrating and No. 5 bulging in and scoring the plate but not penetrating.

No. 6 struck the port side just abaft the second bulkhead, scoring the plate but not penetrating.

Nos. 7 and 8 struck the port side well down and just forward of the first bulkhead and penetrated.

No. 9 struck well down on the starboard side just abaft the stem, penetrating the plate and loosening plate rivets.

No. 10 struck on the starboard side almost at the junction of the side plate and second bulkhead, badly damaging the side plate and then perforating the second, third, and boiler bulkheads, as shown in the bulkhead diagrams. This shot did much more damage than any of the others.

No. 11 struck on the starboard side just abaft No. 9, and perforated the lower angle iron of the first bulkhead.

No. 12 struck just abaft No. 10, and penetrated.

No. 13 struck the lower edge of the port plate, glanced off, and passing under the second and third bulkheads, penetrated a lower corner of the boiler bulkhead.

It will be noticed that most of the shots which penetrated struck in places where the plates had been stiffened by bulkheads or angle irons.

From the direction assumed by No. 10 shot in passing through the bulkheads it is but reasonable to suppose that it struck the ground before striking the boat, and it may be that some or all of shots Nos. 8, 9, 11, and 12 did likewise.

The results of this test were excellent, and plainly indicate the value of the rapid-fire gun for torpedo-boat defense.

GRUSON'S 4.72-INCH RAPID-FIRE HOWITZER.

This howitzer which, at the Gruson firing trials at Tangerhüette, gave the excellent results described under high-angle fire, is the first howitzer to which the falling-block type of the rapid-fire system has been applied. It consists of a single forged crucible steel tube, having a falling block of a form similar to that found in the Gruson rapid-fire guns, but differing in the details of its manipulating and firing mechanism.

This gun is illustrated in Plate IV, and the manipulating and firing mechanism are as described below.

PLATE IV.

GRUSON'S RAPID FIRE HOWITZER

FIG. 1

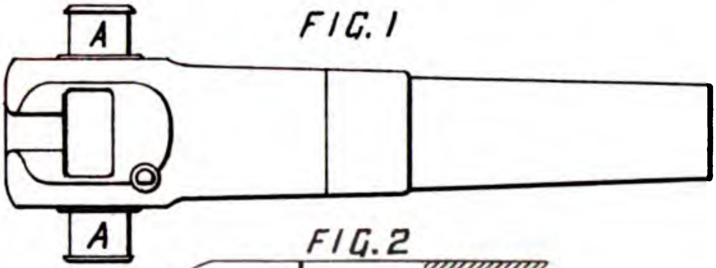


FIG. 2

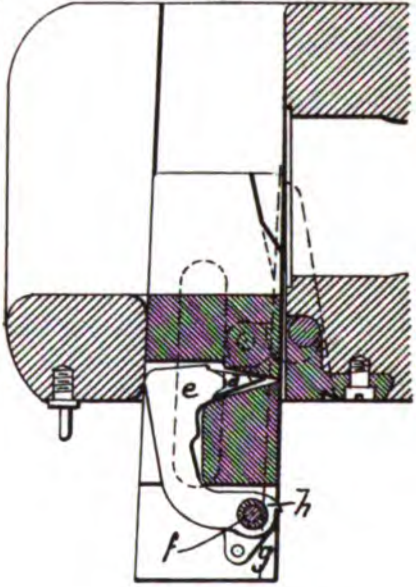
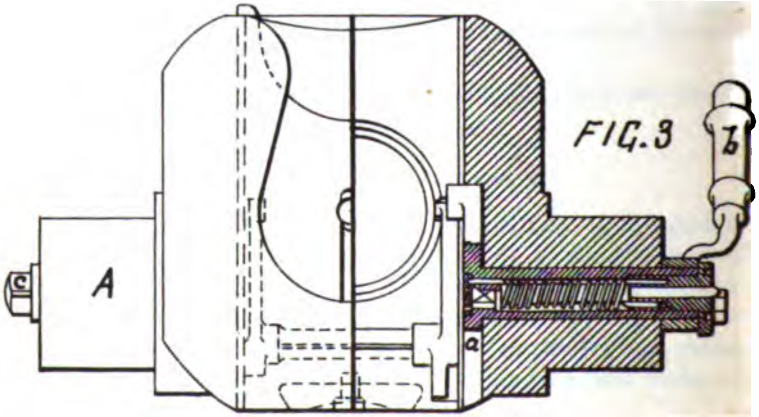


FIG. 3



The trunnions of the piece, AA, Figs. 1 and 3, are abreast the breech-block aperture. To the right one is attached the bell-crank lever, *a*, Fig. 3, the turning of which by its handle, *b*, acts to move the block vertically. In the hollow axis of this lever is a torsion spring (shown in Fig. 3), the inner end of which is connected to the crank and the outer end to a hook, which by means of a pin is kept from revolving with the lever, in consequence of which the spring stretches during the downward movement of the block, thus acting as a support. In the upward movement this acts to decrease the necessary lifting power. The fall of the block is limited by a screw, *c*, Fig. 3, through the left trunnion, which works in a vertical groove in the left side face of the breech block.

The block is locked in the closed position by a locking catch on the right wall of the breech aperture, so fitted as to take behind the lever arm and retain it in place until released by pressure on a connecting lug projecting through the rear of the breech.

Firing mechanism.—This is very simple and consists of a firing pin, *d*, and a hammer, *e*, Fig. 2, mounted on the spindle *f* in such a manner as to hang over to the rear, and provided with a short trigger arm, *g*, to which a firing lanyard is to be attached. A sharp pull on the lanyard will drive the firing pin to the front, and when the lanyard is released the hammer and pin will drop back to the rear. The nose, *h*, on the bearing of the hammer, acts to keep the firing pin from coming to the front until the block is in its locking position.

The details of the howitzer are as follows:

Calibre	inches	4.72
Total length	calibres	11.7
Length of bore	inches	46.7
Length of rifling	do	41.5
Weight of breech mechanism	pounds	83.8
Total weight of gun	do	946
Number of grooves in rifling		24
Charge of smokeless powder, c/89	ounces	12.7
Weight of projectile	pounds	36.2
Muzzle velocity	f. s.	984
Corresponding chamber pressure	tons per square inch	9.4
Probable rate of fire per minute		10
Calculated range at elevation of 34° 30′	yards	5,500

A 13-calibre Gruson howitzer has also been constructed for use in shielded land mounts. The trunnions found in the 12-calibre howitzer are replaced by three trunnion rings.

HOTCHKISS 2.95-INCH (14-POUNDER) RAPID-FIRE GUN.

Result of trials at Silloth, England, July 31 *and August* 1, 1890.

Height of gun above plane of fall.	Elevation.	Weight of charge. Pebble powder.	Weight of projectile.	Muzzle velocity.	Chamber pressure (tons per square inch.)	Range.
Feet.	° ′	*Pounds.*	*Pounds.*	*f. s.*		*Yards.*
28	0 35	7½	14	2,044	16.3	839
28	0 35	7½	14	2,044	15.8	830
28	1 00	7½	14	2,044	15.6	1,440

Twenty-two shots in all were fired, but full details of only the first three have been obtained.

A range of 6,825 yards was obtained at an angle of elevation of 13 degrees, the gun being placed at a height of 37 feet above the plane of fall.

Gun, carriage, and ammunition worked perfectly, the satisfactory manner in which the cartridge cases were extracted being particularly noticeable.

The jump as measured during the last two rounds was—1.9 inches.

KRUPP RAPID-FIRE GUNS.

During the latter part of 1890 Krupp carried on an extensive series of experiments with the armor-piercing calibres of his rapid-fire guns with uniformly excellent results.

The results given in the following table are interesting in showing, for the nearly equal chamber pressures obtained, the relation existing between the charges and consequent velocities in the guns in which grains of similar size were used:

Details.	Krupp 10.5^{cm} R. F. gun. L/35.	Krupp 12^{cm} R. F. gun. L/35.	Krupp 13^{cm} R. F. gun. L/35.	Krupp 15^{cm} R. F. gun. L/35.
Calibre..............inches..	4.13.............	4.72.............	5.12.............	5.87
Kind of powder used........	Smokeless, C/89.	Smokeless, C/89.	Smokeless, C/89.	Smokeless, C/89
Size of powder grain.inches..	Cube, .197.......	Cube, .197.......	Cube, .197.......	.39 by .39 by .197
Weight of charge.......lbs..	5.95............	7.6.............	9.26............	16.65
Weight of projectile....lbs..	26.46............	39.7.............	50.7.............	76.1
Muzzle velocity.........f. s..	2450.............	2349.............	2365.............	2434
Chamber pressure, tons to square inch.	15.5.............	15.4.............	15.3............	15.97
Actual rate of aimed shots per minute.	10...............	9................	8................	7
Character of ammunition....	Fixed...........	Fixed...........	Fixed...........	Fixed.

MAXIM AUTOMATIC MACHINE GUNS.

This type of machine gun, described on p. 364, No. VII, has been officially adopted for the English navy, and a number ordered of a calibre of 0.303 inch to take the new English magazine rifle ammunition. The gun weighs only 50 pounds and has attained a rate of 600 shots per minute.

The maxim 37-mm. automatic machine gun has been frequently experimented with abroad, and has attained a rate of 250 shots per minute. Its principal details are as follows:

Calibre	inches..	1.46
Weight	pounds..	364
Rifling	Uniform, one turn in, calibres..	30
Powder charge	ounces..	2.82
Projectile	pound..	1
Length of complete round	inches .	6.2
Weight of complete round	pounds..	1.46
Muzzle velocity	f. s..	1,319

The Austrians have adopted and are using guns of this type of a calibre of 0.315 inches.

MAXIM-NORDENFELDT RAPID-FIRE GUNS.

The largest calibre of this type constructed up to the present time is the 4.72-inch.

The breech block of this gun is fitted on the interrupted-screw principle, the screw threads and blanks, instead of being parallel to the axis of the block as in the Canet and Armstrong rapid-fire types, being in the form of spirals. The block works in a hinged collar. Studs in the collar are fitted to travel in curved grooves cut in the surface of the block in such a manner as to cause the block and collar, when the breech is opened, to drop to the right around an axis parallel to the bore of the gun.

The principal details of this gun are as follows:

Calibre	inches..	4.72
Total weight	tons..	2.5
Total length	calibres..	48.9
Powder charge (ordinary powder)	pounds..	25
Weight of projectile	do..	45
Calculated muzzle velocity	f. s..	2,200

Some interesting trials have been carried out this year with a 6-pounder (2.24 inch) Maxim-Nordenfeldt rapid-fire gun. In one trial in England five rounds were fired at a Vickers 4-inch steel plate at a range of 100 yards. Armor-piercing projectiles were employed. At the last shot a charge of 13 ounces of Maxim smokeless powder was used which gave a muzzle velocity of 2,200 f. s. and caused the projectile to perforate the plate.

Of the calibres of the Maxim-Nordenfeldt rapid-fire guns which have been constructed up to date, the following are those which have been fitted with the Maxim automatic breech mechanism.

3 inch, 14-pounder, with a rate of about 35 unaimed shots per minute.
2.57 inch, 9-pounder, with a rate of about 45 unaimed shots per minute.
2.24 inch, 6-pounder, with a rate of about 50 unaimed shots per minute.
1.85 inch, 3-pounder, with a rate of about 60 unaimed shots per minute.

The 3-pounder has actually fired 60 shots in 61 seconds.

The Austrian Government has ordered a 3-inch gun of this type, presumably for experimental purposes.

SKODA RAPID-FIRE GUN.

This gun, referred to on page 112, No. IX, has been officially adopted by the Austrian Government. It is illustrated in Plate V.

Breech block.—This is a vertical falling block, with its front and rear faces inclined as in Figs. 4 and 6. It is guided up and down in the breech opening by means of projections on its side faces fitted to work in grooves X, cut in the sides of the breech opening. The downward motion is limited by the set screw Y, Fig. 5, which projects into a vertical groove, Z, Fig. 5, cut in the left face of the block. The upper surface of the block is scored out in such a manner as to permit the introduction of the cartridge with the least fall of block. A face plate, U, Fig. 4, with its edges rounded, is fitted to the front face of the block. This block is raised and lowered by means of a hand lever, A, Fig. 4, attached to the spindle B. To this spindle is secured a crank arm, C, which works in a recess cut in the right side of the breech block. The other end of this crank arm is connected by a fixed screw, *c*, to one end of a connecting rod, D, the other end of which is secured to the breech block by a pin, *d*.

Firing mechanism.—Passing transversely through the block is a spindle E, Figs. 2, 4, and 6, on which are fitted two arms by means of which the firing pin is brought to the cocking position. One, *e*, Fig. 4, working in the right-hand recess of the block directly under the connecting rod D; the other, a cocking arm, *e'*, working in a slot in the middle of the block, Fig. 5, through the upper part of which passes the firing pin F and its spring, *f*, Fig. 2. Through this central slot, but below the spindle E, passes a second spindle, G, Fig. 2, on which is mounted a double armed lever, *g g'*, the vertical arm *g* of which is pressed against the bearing of the cocking arm *e'* by the sear spring H. The trigger nose I, Fig. 2, takes against the extremity of the horizontal arm.

Extractors (Figs. 3 and 5).—These are double and consist of a spindle, K, upon which a sleeve, L, is fitted; in one with the sleeve are two extractor arms *l l*, recessed at their upper ends, and a curved toe, *m*, which is fitted to work in a score which decreases in depth from bottom to top as shown in Fig. 4, in the forward lower part of the block.

To serve the gun.—Revolve the lever A backward and the crank-arm *c* will move to the rear and downward. At first, until the crank-arm C and connecting rod D straighten out in the same right line, the block

PLATE V.

SKODA R.F. GUN.

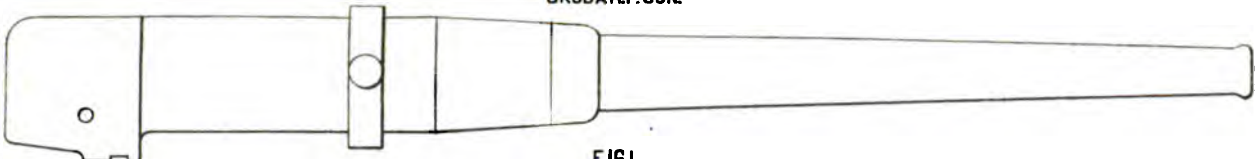


FIG. 1

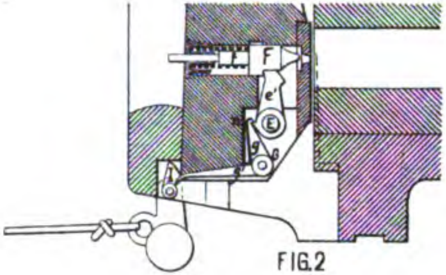


FIG. 2

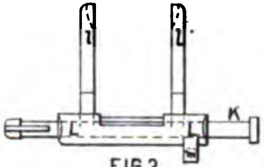


FIG. 3

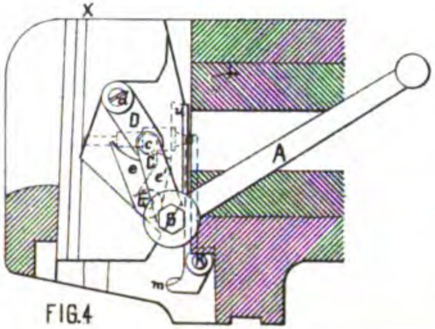


FIG. 4

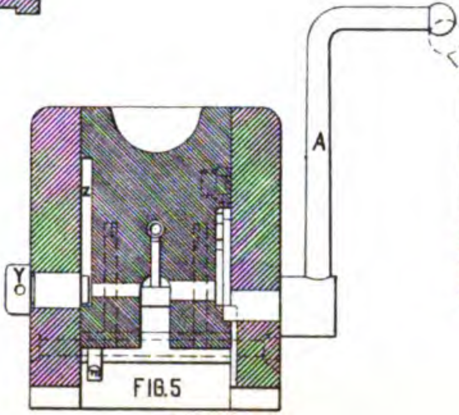


FIG. 5

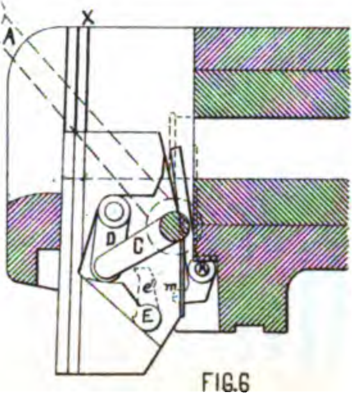


FIG. 6

will rise a little, after which C and D will make a decreasing angle to the rear until the block is down to the loading position. As the block descends the toe, *m*, of the sleeve of the extractor, Fig. 6, is pressed to the front by the decreasing score in the block and gradually withdraws the empty cartridge case until *m* reaches the top of the narrow score, where it receives a sudden sharp movement to the front which causes the extractors to throw the empty case out of the bore to the rear. During this falling movement of the block the connecting rod D takes against the arm *e*, forcing it down and causing the toe of the cocking arm *e'* to take against a projection on the under surface of the firing pin F, forcing the firing pin to the rear against the pressure of its spring, *f*, until the toe of the arm *g* of the sear takes in a projecting notch, *n*, Fig. 2, in the bearing of the cocking arm *e'*, which, by the pressure of its spring, retains the firing pin in the cocking position. In order to insure certainty of thus cocking the piece the continued falling of the block causes the projecting notch *n* to go a little beyond the cocking position, and then to come back to it as the block reaches the end of its travel.

The cartridge is now introduced, and the block raised by a forward movement of the lever A. The positions of the crank-arm C and the connecting rod D at an angle forward of the right line connecting their pivots act to lock the block against accidental opening on firing.

To fire.—Pull the trigger, and its nose, I, will press down on the arm *g'* and force the arm *g* back clear of the projecting notch *n*, thus suddenly releasing the firing pin.

HIGH-ANGLE FIRE.

The employment of rifled breech-loading mortars and howitzers for high-angle fire in coast defense has been receiving much attention of late years, and a number of such guns have been constructed and experimented with by Armstrong, Canet, Gruson, and Krupp, the degree of success attained by each depending upon its mount. France and Italy have many mortars and howitzers mounted and in position.

It is proposed to have such mounts on board ship, principally for use where direct fire is impossible. Many of the large English war vessels now building are to have at least one in the bow. The mount described on page 81, No. IX, and the Canet mount herein described are considered very desirable for this purpose.

Following are details of interesting experiments, which will give an idea of the possible accuracy of this kind of fire under the most favorable conditions.

KRUPP'S MEPPEN EXPERIMENTS.

One of the many firing experiments carried on by Krupp at Meppen was against a target representing the horizontal crown of a protective deck, the details of which are interesting as showing the effect at long ranges of armor-piercing projectiles discharged from a rifled howitzer, at high angles and with low velocities.

Details of target.—This, which was 52.5 feet long, 13.1 feet wide, and 3½ inches thick, was built up of three 1-inch and one ½-inch steel plates riveted to seven heavy longitudinal steel ribs secured in a horizontal position to a bed of wood of such thickness as to bring the plate to a distance of about 5½ feet above the ground.

Ballistical details.

[Gun used, Krupp's 28.55 centimetre (11.24-inch) rifled howitzer.]

Length of bore	calibres	10
Weight of howitzer	tons	10¼
Projectile (forged steel armor-piercing)	pounds	661.5
Range (1.9 knots)	yards	3,870

Firing details.—Three series of shots were fired.

First series.

Number of shots fired		10
Charge of black powder	pounds	25
Angle of elevation	degrees	45
Angle of impact	do	46¼
Striking velocity	f. s.	610
Striking energy	f. t.	1,706
Maximum deviation in range	feet	95
Maximum deviation in direction	do	27

Only one hit was made, the point of impact of which was distant from the middle point of the plate by 6½ feet short in range, and 19 inches in direction. The projectile perforated the plate and penetrated 5 feet into the earth, bending in the first rib to the left of the point of impact to a depth of about 10 inches and loosening 10 rivets. The entire plate was bent, the depression at its middle point amounting to about 1½ inches.

Second series.

Number of shots fired		16
Charge of black powder	pounds	33.8
Angle of elevation	degrees	65
Angle of impact	do	66
Striking velocity	f. s.	751.3
Striking energy	f. t.	2,588
Maximum deviation in range	feet	105
Maximum deviation in direction	do	88.5

Only one hit was made, the point of impact of which was distant from the middle point of the plate by 5 feet over in range, and 20 inches in direction. The projectile perforated the plate and penetrated 3½ feet into the earth, bending in the nearest rib to a depth of 17 inches and breaking 13 rivets. The entire plate was bent, the depression at its middle point amounting to about 3.5 inches.

Third series.—Twenty shots were fired at an elevation of 65 degrees but no hits were made.

Two-thirds of the number of shots of the first and second series struck within an area less than that presented by the decks of the majority of the larger men-of-war now afloat, but it must be remembered that the gun was mounted on a steady platform, the range was accurately known, and the target was fixed.

JAPANESE EXPERIMENTS.

Experiments, very similar to those at Meppen, were carried out in Japan in March of this year with a howitzer and a mortar, each made at the Osaka Arsenal.

The target, which represented an athwart-ship section of the protective deck of the lately constructed coast defense vessel *Matsushima*, was 59 feet long, 17.3 feet broad, and 2.95 inches thick, being composed of three equal thicknesses of Schneider's steel riveted together.

This target was shaped to the form of the protective deck of the *Matsushima*, and was placed horizontally, with its longer axis in the plane of fire.

The following are the principal details of the experiments:

	Gun used.	
	28^{cm} (11-inch) howitzer.	27^{cm} (10.6-inch) mortar.
Length in calibres	9	7
Charge of pebble powder	20.9 pounds	11 pounds.
Chilled cast-iron projectile	478.5 pounds	269 pounds.
Muzzle velocity	715 f. s	715 f. s.
Angle of elevation	58 degrees	60 degrees.
Angle of impact	61 degrees	63 degrees.
Range	3,770 yards	3,553 yards.
Number of shots fired	45	73
Number of hits made	3	4
Mean error in range	134.5 feet	181.2 feet.
Mean error in direction	26.2 feet	49.2 feet.

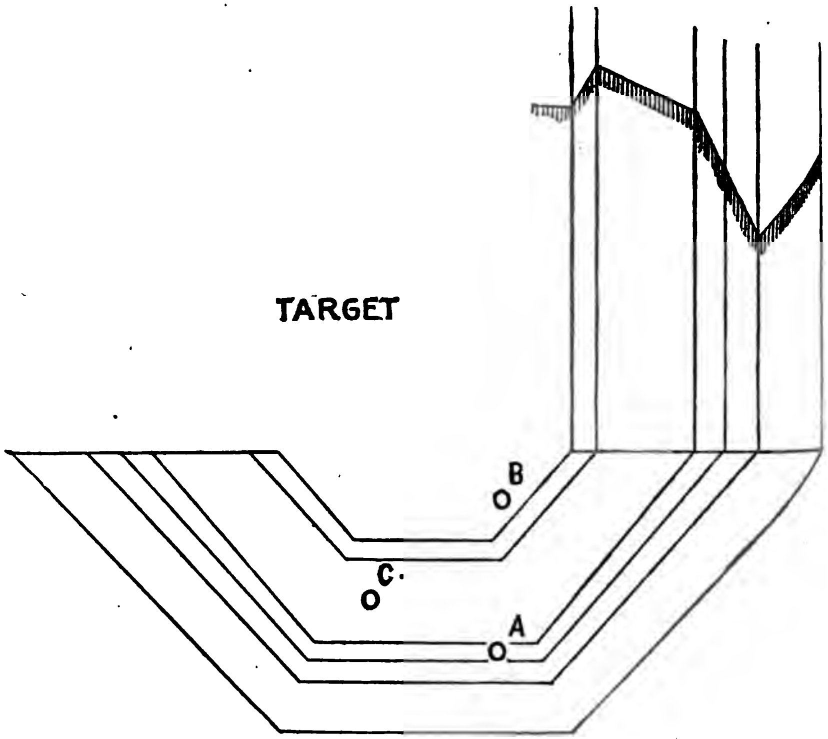
Only seven hits were made out of the 118 shots fired, but 16 others struck the ground around the target within an area representing the deck of the *Matsushima*.

Two of the seven shells which struck the target contained bursting charges, and were fitted with a new delayed-action fuze of Japanese design. Each of these perforated the target and burst after penetrating over 6 feet in the ground under the target.

GRUSON'S TANGERHÜETTE EXPERIMENTS.

One of the most interesting of the many firing experiments carried on by the Gruson firm last September was that of a 4.72-inch rapid-fire howitzer, mounted on a field carriage, at an earthwork showing a front of 32.8 feet, at a distance of 3,281 yards.

The principal details were as follows:



Details of gun.

[Gun, Gruson's 12-centimetre (4.72-inch) R. F. howitzer.]

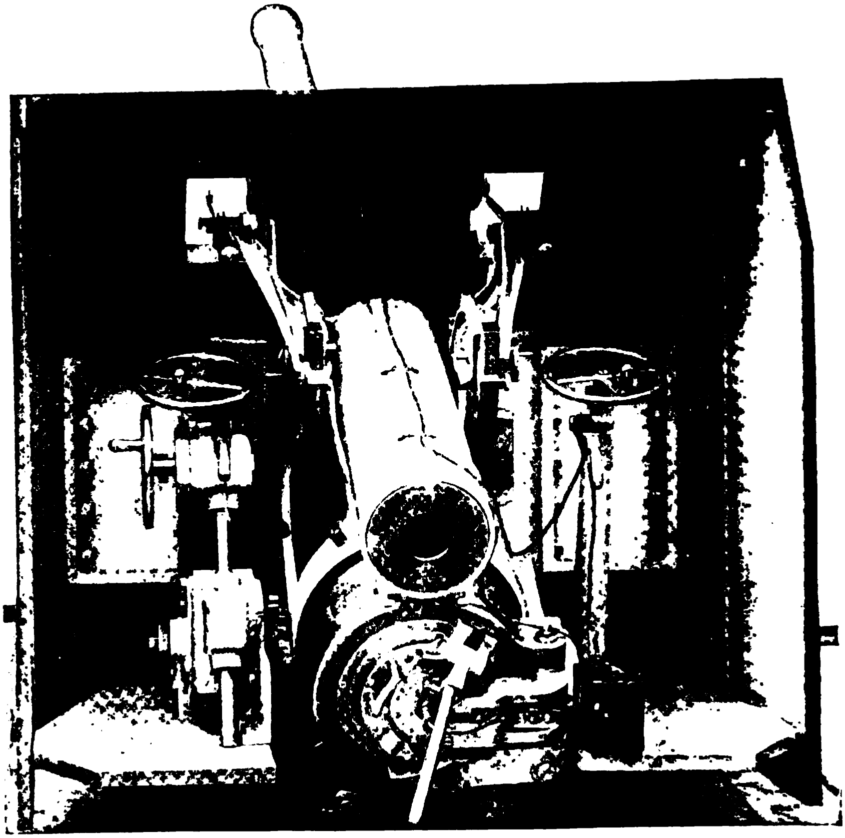
Length of bore	calibres	9.9
Total length of gun	do	11.7
Weight of gun	pounds	946
Length of rifling	calibres	8.8
Weight of charge, smokeless, c./89	ounces	8.8
Weight of shell and shrapnel	pounds	36.2
Number of balls in shrapnel		450
Muzzle velocity	f. s.	767.7

Firing details.—Twenty shots in all were fired, the first ten with shell, the remainder with shrapnel, the elevation for all but the first being between 18° and 19°. Two of the ten shells hit the target, the remainder striking in the space included between points 44 yards short and 219 yards over. One of the shells struck the superior slope of the earthwork at A; the other struck just inside, at B, and burst. The first shot was fired at an elevation of 20⅝° and went 219 yards over. The elevation was then decreased, and the remaining shots struck in a space included between points 44 yards short and 55 yards over.

With the ten rounds of shrapnel the fuzes were set for from 14.8 seconds to 15.3 seconds, and one direct hit was made at C; all the remaining shrapnel burst in a space included between points 55 yards short and 22 yards over.

This practice was considered to have been very good.

VAVASSEUR'S 6-INCH R. F. GUN MOUNT.



GUN MOUNTS.

One of the most important subjects now engaging the attention of ordnance officers is that of the most advisable manner of mounting and working heavy guns on board ship.

It is reasonable to suppose that the present muzzle velocities are quite certain to be increased in the near future, and as the work done on a mount is proportional to the square of the velocity of recoil, which varies as the muzzle velocity of the projectile, it follows that the first condition necessary with the modern gun mount is that of greater strength, sufficient to withstand the strains produced by the increased recoil energies.

Other necessary conditions are those due to the limited space available on board ship and to the lightness and lack of rigidity of the gun platform. The most essential of these are as follows:

Light weight combined with sufficient strength to withstand all possible strains.

Economy of space and simplicity of all working parts.

Capability of being trained and worked with ease and rapidity under all conditions of sea and weather up to the instant of firing.

Certainty, simplicity, and reliability of recoil-checking arrangements.

The degree of success attained in approaching to these conditions can be best exemplified by descriptions of some few mounts and recoil checks now in use in foreign countries.

The German naval authorities object to any ordnance that can not be worked by hand, and will not admit hydraulic gear on board ship for gun mounts.

The English have mounted 10-inch breech-loading rifles on the *Thunderer* on gravity return carriages, the gun having no appreciable preponderance, and its trunnions being fitted with antifriction knife-edge pivots resting on strong adjustable springs fitted to the carriage.

The use of electric gear for gun mounts is increasing, and gives, as compared with hydraulic gear, not only an advantage in weight, space, and safety, but a greater facility for training in elevation and direction, thus insuring greater rapidity and accuracy of fire.

VAVASSEUR C. P. RAPID-FIRE GUN MOUNT.

This mount, Plates VI and VII, which has been adopted by the English naval authorities for the Armstrong 6-inch rapid-fire guns, consists of three principal parts: a tubular cradle, an underframe, and a base. The gun is fitted to slide within the tubular cradle. Trunnions on each side of the cradle fit in bearings in the underframe. The underframe is pivoted in and revolves upon the base.

Extending downward from the rear of the gun are two stout lugs, one on each side. Keyed to the top of the gun so as to move with it, as shown in the cut, is a return recoil cylinder containing a strong spring.

The tubular cradle is fitted with trunnions which take in bearing blocks A, Plate VII, Figs. 1 and 3. These blocks fit into slots in the underframe B, Figs. 1 and 2, and are locked in place by adjustable screws. From the top of the front part of the cradle projects a stout lug to which is bolted the piston rod of the recoil cylinder. To the bottom of the rear part of the cradle are riveted the two recoil-check cylinders, the piston rods of which are bolted to the lugs on the rear of the gun, as indicated in Plate VI. These cylinders communicate, and the recoil checks are of the Vavasseur type.

The base C, Fig. 1, Plate VII, is bolted to the deck. The underframe rests on this base, to which it is confined by two strong clips D. Into the bottom of the underframe is screwed a central vertical pivot E, which takes in a corresponding socket in the base and rests on springs F. The springs bear against a plate, G, resting on a nest of anti-friction rollers, *g*. The plate G is fitted with a central stem, *g'*, which, by means of an adjustable nut, is used to keep the springs from lifting the underframe to such a degree as to bring the clips into hard bearing.

Train in direction is given by means of hand wheels H H, Figs. 1, 2, and 3, on each side of the mount, which, by means of rods *h*, pinions *h'*, Fig. 2, and bevel wheels *h*,'' actuate a worm, I, Figs. 1 and 3, which gears into the teeth of a rack, J, Fig. 1, formed around the greater part of the circumference of the base.

Train in elevation is given by means of the hand wheel K, Figs. 2, 3, and 4, on the left side of the mount, which, by means of a rod and gearing, actuates the pinion L, which gears into a toothed elevating rack, M, Fig. 4, secured to the side of the cradle.

The sight bars are fitted to slide in tubular bearings. These bearings are jointed to arms projecting upward from the cradle in such a manner that they can be elevated and depressed around the joints as pivots. This movement is given by means of pinions, at the rear ends of the bearings, working on graduated arcs.

CANET MORTAR ON NAVAL MOUNT.

This was designed for use on board ship in the hope that it would result in giving the least possible strain to the deck forming the gun platform.

Fig. 1, Plate VIII, illustrates this mount with the mortar loaded and ready for firing at a high angle. It is a central pivot fitted to revolve on rollers. The rocking arms A, which contain the trunnion bearings, revolve about the shaft B of the underframe C, and two balancing arms, which are fitted to and extend below the shaft B, contain recesses for trunnion bearings, the trunnions of which guide the recoil cylinders to and fro.

Elevation of the chase is given by means of the elevating lever arms

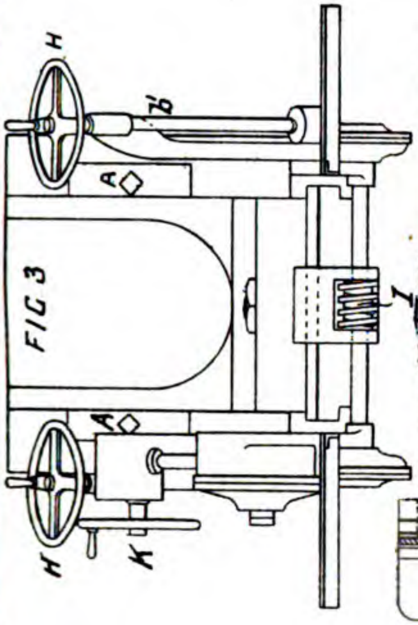


FIG. 3

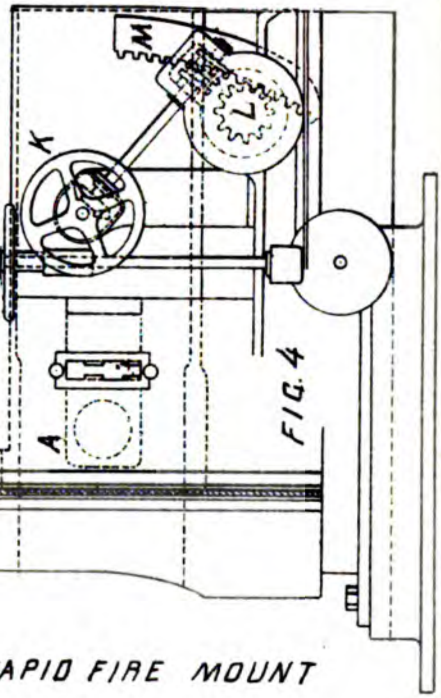


FIG. 4

VAVASSEUR C.P. RAPID FIRE MOUNT

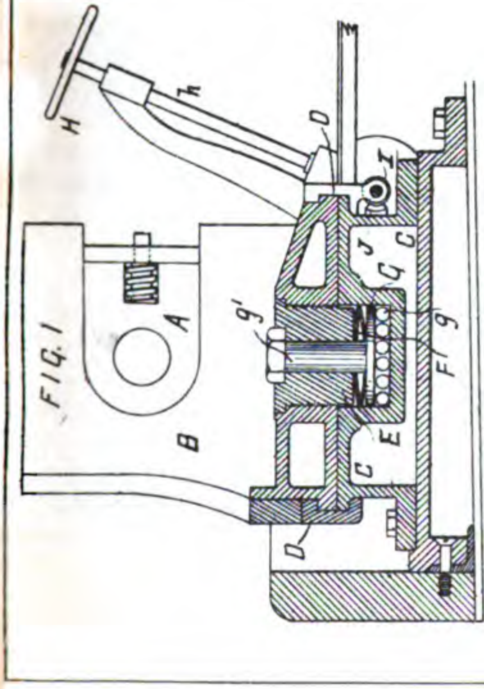


FIG. 1

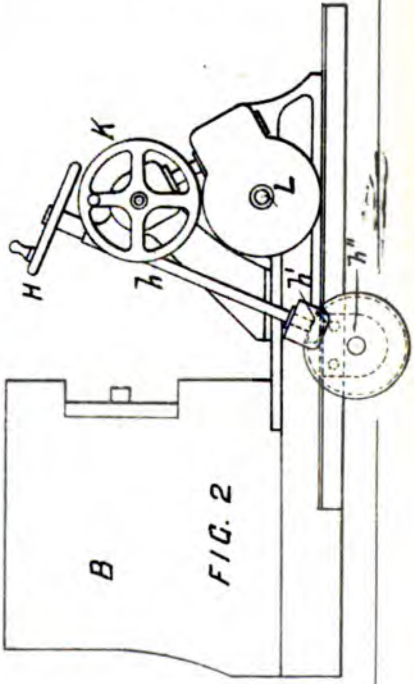


FIG. 2

PLATE VIII.

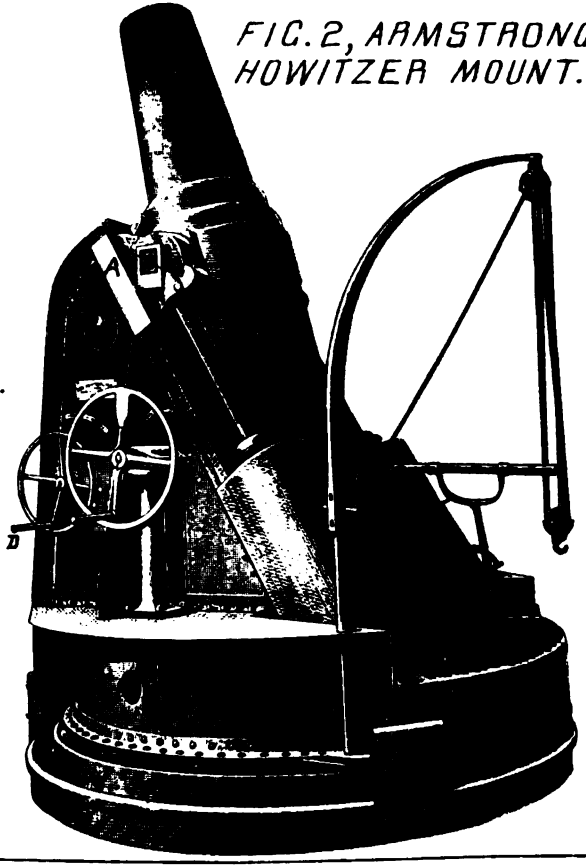


FIG. 2, ARMSTRONG HOWITZER MOUNT.

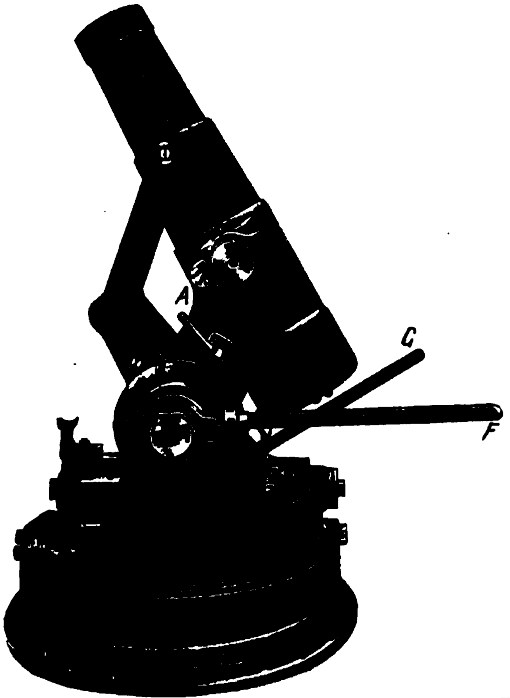


FIG. 1, CANET NAVAL MORTAR MOUNT.

D and E, the arms D turning on bearings on the shaft B through the action of the elevating lever F, and being locked, when the mortar is at the desired elevation, by a screw.

Some details of this mortar may be of interest:

Calibre		inches..	5.91
Total weight		pounds..	992
Total length		calibres..	8
Length of bore		do..	6.4
Rifling	Length	do..	5.4
	No. of grooves		46
Weight of charge		pounds..	3.3
Weight of projectile		do..	70.4
Muzzle velocity		f. s..	656
Maximum range		yards..	3,641

BREECH-LOADING RIFLED HOWITZER MOUNTS.

Armstrong.—Fig. 2, Plate VIII, is a cut of an VIII-inch B. L. R. howitzer constructed by Sir Wm. Armstrong for high angle fire, and so mounted as to give elevations up to 75°.

The carriage, A, is formed of two stout steel frames rigidly bolted together in such a manner as to allow the gun to be brought to a horizontal position, and fitted with bearings for the howitzer trunnions and with lugs to which the hydraulic cylinder piston rods are secured. The carriage is fitted to slide on inclined bearing surfaces of an underframe, along which it is guided by stout clips.

The underframe, B, is formed of two parallel steel frames bolted to a curved cross piece in front and rigidly secured to the upper part of the base C, fitted to revolve on live rollers, as shown in the cut. The sliding surfaces for the carriage are inclined at an angle of 60° with the horizontal. The hydro-pneumatic recoil cylinders are bolted to the underframe, one on each side, and each contains an air chamber and hydraulic chamber connected by a recoil and a passover valve, and each chamber connected to its corresponding one in the other cylinder by an independent pipe which serves to equalize the recoil pressures.

This howitzer is always brought to a horizontal position for loading. This is accomplished, after firing, by elevating gearing actuated by means of hand wheels, D, one on each side of the underframe. When loaded, it is given the desired elevation, and then run up the slide by opening the passover valves which serve to open communication between the air and hydraulic chambers.

Train in direction is obtained by means of the hand wheel E, which, by means of gearing, actuates a pinion at the foot of the vertical shaft shown in the cut which engages in training gear secured to the racer.

The effect of fire from howitzers of this description is described in remarks under High-Angle Fire.

Canet.—A howitzer mount for high-angle fire, designed by M. Canet, and adopted for use in the French Army and Navy, is illustrated in Figs. 1 and 2, Plate IX.

The carriage, A, is supplied with trunnion bearings, *a*, and the hydraulic cylinders, *a′ a′*, and is fitted with clips to guide it on the slides of the underframe, the slides being inclined at an angle of about 5 degrees to permit of a slow gravity return after recoil. The underframe, B, has parallel sides and a circular base, all being rigidly united by flanges in such a manner as to permit an elevation of about 60 degrees being given to the howitzer. The hydraulic recoil checks are of the Canet central counter rod type shown in Fig. 2, Plate XI.

Training in elevation is performed by revolving the crank lever F, which, by means of a shaft and gearing, works a quadrant fitted to the side of the gun.

Training in direction is performed by revolving the crank lever C, which, by means of gearing and a guide wheel, causes the chain D to revolve the base E. With a 10.6-inch howitzer thus mounted one man can easily train the piece either in elevation or direction. This howitzer is always brought to a horizontal position for loading. With large calibres the projectile is placed in a holder, G, and then revolved to a position at the breech, in line with the axis of the bore, by means of gearing actuated by the crank handle H. This is a central pivot mount fitted to revolve on live rollers.

The patent rights for some of the Canet mounts have been acquired by a leading firm of English manufacturers.

GRUSON'S BOAT MOUNT.

(Plate X.)

This mount has given such satisfaction at the maker's trials that a reference to its principal details may be of interest.

The upper carriage consists of two steel plates, A, Figs. 1 and 2, Plate X, the trunnion bearings, *a*, Fig. 1, of which receive the trunnions of the gun. These two steel plates are fitted to turn about a horizontal spindle, *b*, passing through an undercarriage, B. This undercarriage terminates in a pivot, *c*, Fig. 2, fitting in a socket in the base column D, the function of which is to permit lateral rotation of the mount.

On a revolving ring, E, Fig. 2, fitting in a score in the base column D, two recoil-check cylinders, F, are bolted, the spring loaded piston-rods of which are connected to the lower parts of the plates forming the upper carriage by eyes, G, Fig. 1. The shoulder-piece H, Fig. 1, which revolves about the spindle *b* is used to give vertical train by means of the rods *m* and *n*, Fig. 1. By means of a pin the shoulder piece is connected to a cylindrical pipe, K, which is fitted to slide up and down on the rod *n*, and is connected to the gun by means of the connecting rod *m*. This pipe is slitted and is clamped in any position by means of a screw actuated by the lever *h*. The rod *n* is fitted to turn about a pin, *o*.

PLATE IX.

FRENCH SERVICE HOWITZER

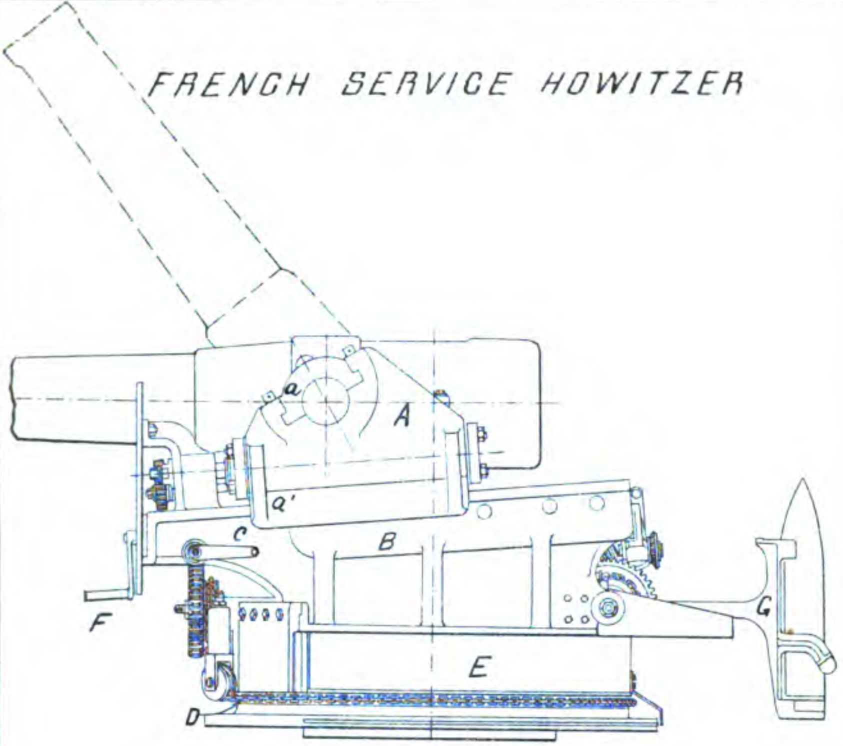


FIG. 1

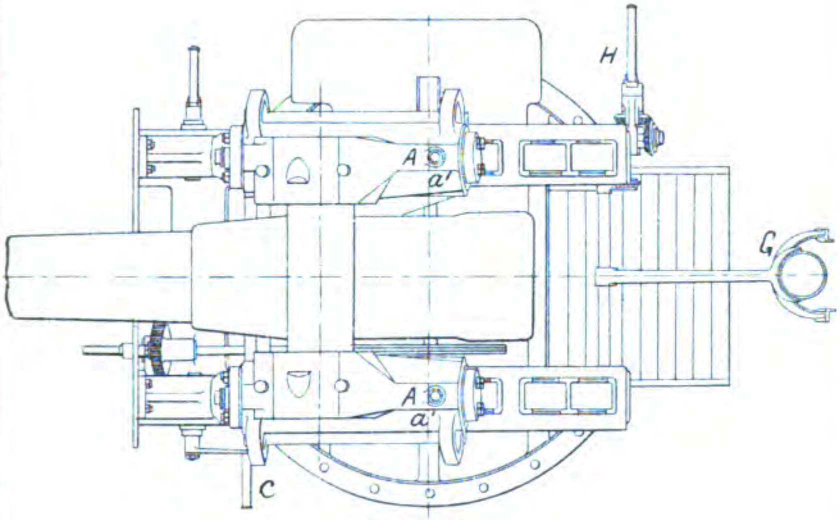


FIG. 2

PLATE X

GRUSON'S BOAT MOUNT FOR 1.46-IN. (1 PD'R) R.F. GUN

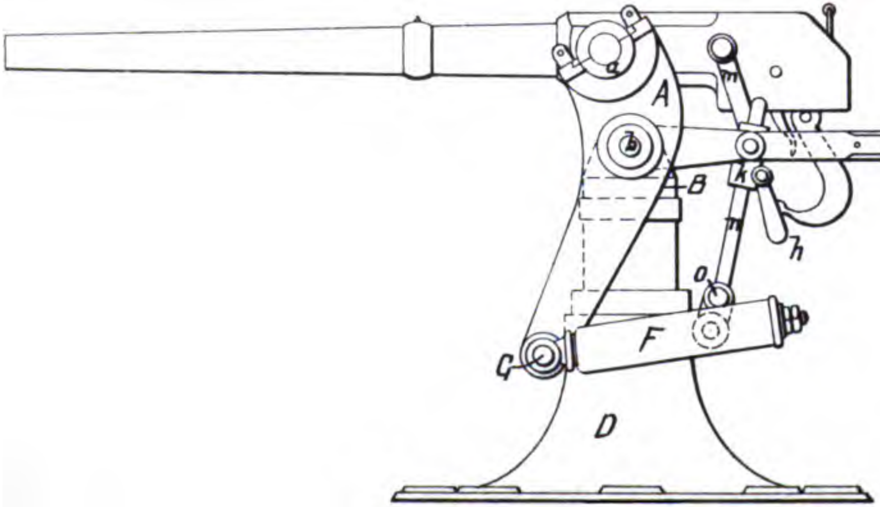


FIG. 1

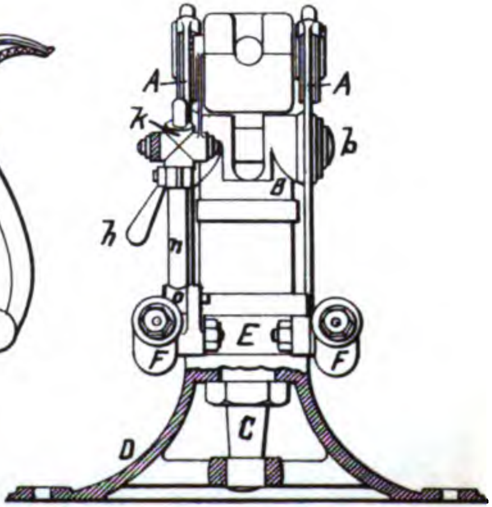


FIG. 2

In practice, as the gun is moved vertically by the shoulder piece, the cylindrical pipe K slides on the rod *n* until the proper degree of train is obtained, when it is clamped by means of the handle *h*.

Train in direction is obtained by revolving the under carriage on its pivot C, Fig. 2, by means of the shoulder piece.

One great objection to this mount is its weight—about 198 pounds.

RECOIL CHECKS.

The available space for high power guns on board ship is generally so restricted as to render it most desirable to reduce recoil to a minimum. Of the various systems of recoil checks designed for this purpose we will only refer to some of those known to be in use abroad in which the escape openings are variable and the resistance constant, a condition which is believed to conduce to the greatest reduction of strains on the mount and platform.

In comparing various types it will be well to bear in mind that the following qualities are essential to a good recoil check:

To offer no resistance when recoil commences and to come to rest gradually, so as to bring no undue shock on working parts.

To offer a uniform resistance and to work with regularity and ease.

To be simple and not easily deranged. The fewer parts the better, and those easily accessible.

Permanent adjustability of degree of recoil.

Certainty of holding gun and carriage in a seaway.

Regulation of pressure in connecting pipes.

Capability of storing up energy of recoil for returning gun to firing position without undue shock.

Of the several principal types, one, the Vavasseur, will be found described on page 152, No. VIII. This, with modifications for the various types and calibres of guns, is the English standard recoil check. The best proof of its excellence is exemplified by an English 6-inch B. L. R. mount containing it, which, between 1881 and 1887, was fired over 2,500 times, after which the check was in a perfectly serviceable condition.

Great care is necessary with this and all other checks. An accident occurred the past year illustrating this necessity. Through carelessness the liquid in one of the recoil cylinders of a turret mount on H. M. S. *Camperdown* was allowed to freeze, the result of which was a fractured cylinder.

CANET RECOIL CHECKS.

Fig. 2, Plate XI, shows a section of the simplest example of this check, some form of which is in almost general use with late French mounts for high-power guns, and is also found on the mounts of one or more English, Greek, Japanese, and Spanish men-of-war. The section shown is fitted to gravity-return carriages as illustrated in Fig. 1, which represents Canet's 5.91-inch central pivot naval mount on live rollers.

The piston rod *a* is hollow for a good part of its length as shown in Fig. 2. A central counter rod, *b*, is bolted to the cylinder head at *c*, and fitted to slide in this hollow. This counter rod, which is of circular cross-section throughout its length, varies in diameter in accordance with results of variations in recoil pressures determined by practical experiments. In the piston A are four openings, *d*, closed by an annular spring loaded valve *e*. The action of this check is as follows: During recoil after firing the gun, the compression of the liquid in the cylinder forces back the valve *e*, and allows the liquid to flow to the front part of the cylinder through the openings *d* and the annular space *f* in the piston. The area of this annular space is gradually decreased by the increasing diameter of the counter rod *b* to nothing, when the recoil ends, at which time the front of the cylinder and the space *g* are filled with the liquid. During the gravity return of the gun to firing position the compression of the liquid in the front of the cylinder forces the annular valve *e* into its seat and closes the openings *d*, the liquid then escaping to the rear part of the cylinder through small regulating return apertures, *h*. During this return the liquid in the space *g*, which can only escape through the small channel *i*, is compressed and acts as a buffer to prevent violent shock at end of return.

This form of check is designed for gravity-return carriages, and has been found to act very satisfactorily.

For mounts of heavier guns, particularly those which recoil in a horizontal plane, the regulating return valves described above are dispensed with and one or more auxiliary cylinders—accumulators—used to obtain the same result. These accumulators are placed between the two recoil cylinders, and each contains a plunger. If only one accumulator is used the transverse sectional area of its plunger is equal to that of the two recoil cylinder piston rods. If two accumulators are used, one for each recoil cylinder, the transverse sectional area of the plunger in each is equal to that of its recoil cylinder's piston rod.

The recoil end of each cylinder is connected by a pipe to a valve box containing a spring-loaded valve, which connects with the plunger end of the accumulators. During recoil the same action of the fluid takes place as with the check described above, but as at the rear of each recoil cylinder the volume is diminished by that of its piston rod, an equivalent volume of liquid will pass through the pipe to its accumulator as soon as the pressure exerted is sufficient to open the spring-loaded valve in the valve box. As soon as the recoil is finished this valve takes in its seat and the gun is held until communication is again opened with the recoil cylinders.

The above is practically the form of a Canet recoil check which is fitted to the Whitworth 10-inch gravity-return turret mounts of H. M. S. *Devastation.* The recoil check consists of two recoil cylinders and a

PLATE XI.

CANET RECOIL CHECKS

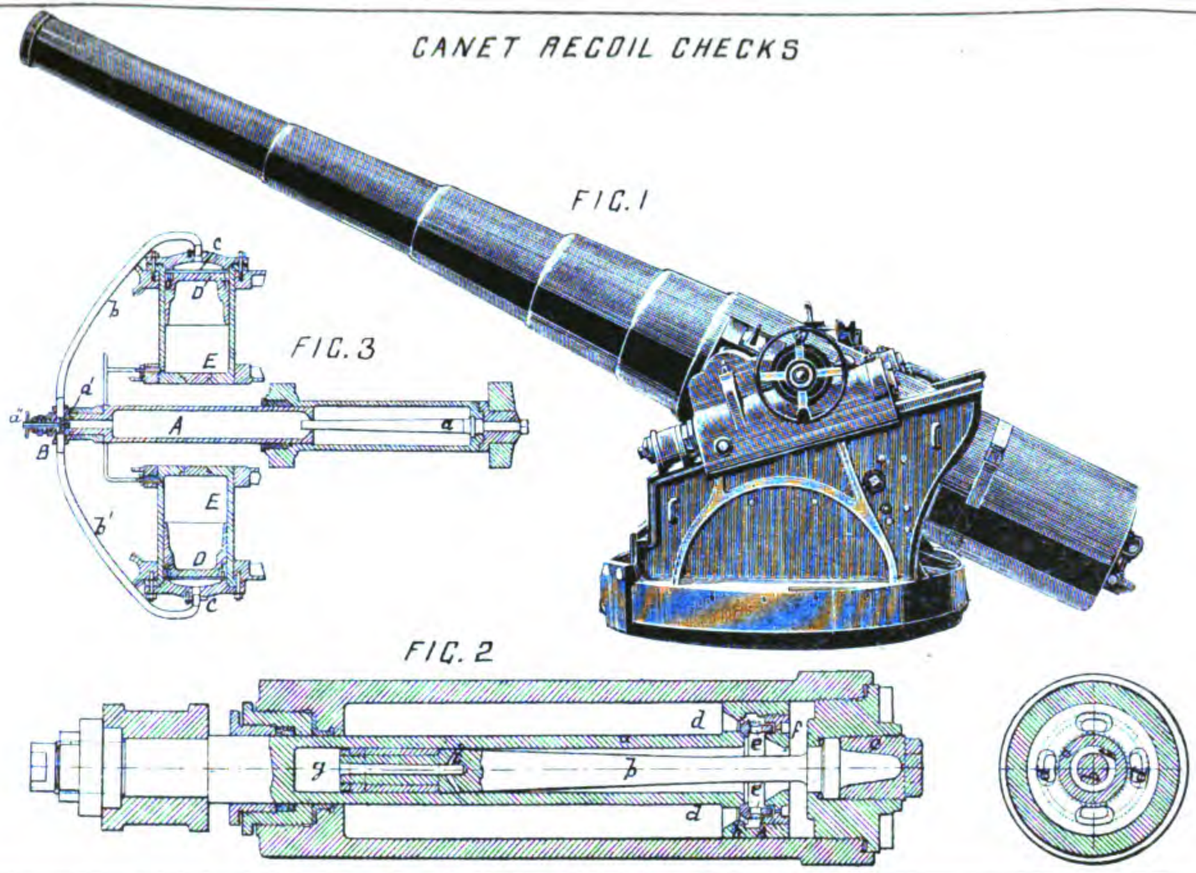


FIG. 1

FIG. 2

FIG. 3

PLATE XII.

JAPANESE BARBETTE MOUNT FOR CANET 12.6-INCH, 65-TON GUN.

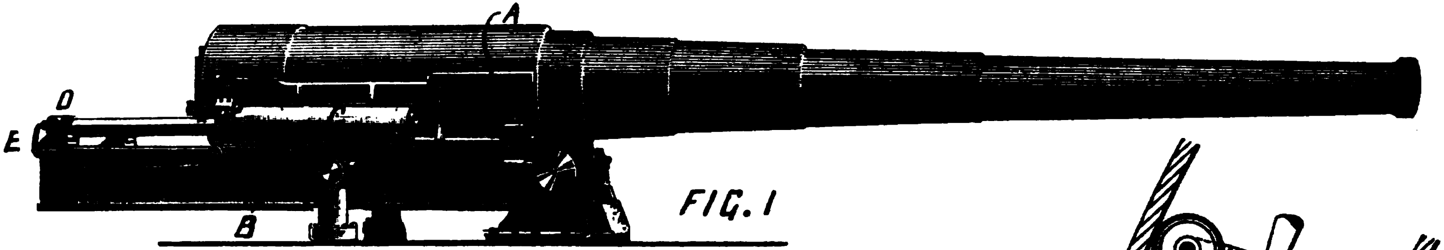


FIG. 1

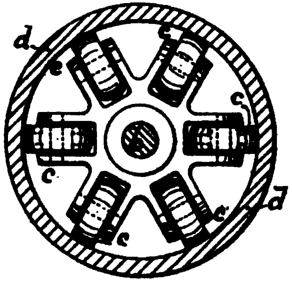


FIG. 4

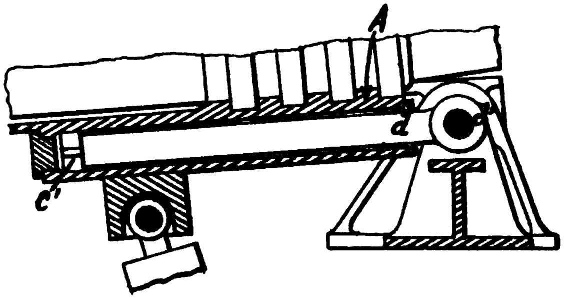


FIG. 2

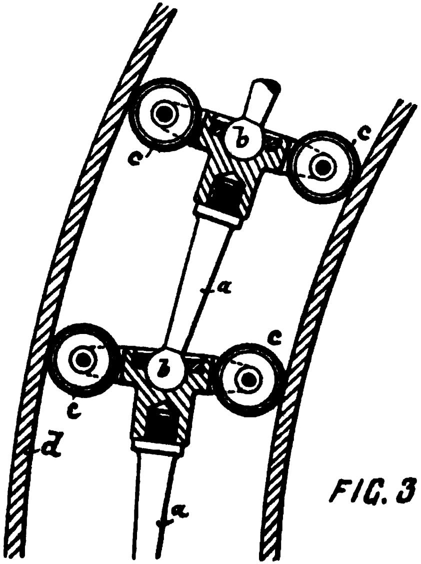


FIG. 3

single accumulator, which will be found described and illustrated in Brassy's Naval Annual for 1891, page 309.

The largest naval mount, to which a slightly modified form of this last described check has been applied, is that of the Canet 12.6-inch, 65 ton guns of the lately constructed Japanese coast defense vessels. This mount, which has withstood the heavy strains of 20 rounds without showing the least sign of weakness, as described on page 128, is illustrated in Plate XII.

The trunnion bands on the gun fit into corresponding slots in the cradle A. This cradle is clipped to, and arranged to move upon, the slides of the underframe B, Fig. 1.

To each side of the cradle is fitted a recoil cylinder, C, Fig. 1, the main piston rods of which are secured to the lugs D on the rear end of the underframe. The accumlator C, Fig. 2, is fitted to the lower part of the cradle with its plunger rod, *d*, secured to the hollow trunnion cross-piece, *d'* at the front of the underframe. The recoil cylinders and accumulator are connected as described above.

When the gun is fired the two recoil cylinders and the accumulator all run in with the gun and cradle, the overflow from the cylinders passing over to occupy the space made vacant in the accumulator, and as soon as the recoil is finished the intervening spring-loaded valve closes and the gun remains at rest.

To run the gun out, water under pressure is admitted through the pipe E, Fig. 1, to the hollow piston rod of the recoil cylinder, through which it passes, and, taking against the cylinder head, runs the gun out, in the mean time the opening of a valve permitting the liquid in the accumulator to escape.

To run the gun in without firing, water under pressure is admitted through the opposite trunnion and hollow rod of the plunger *d*, Fig. 2, to the head of the accumulator, the liquid in the recoil cylinders at the same time being permitted to escape. Train in elevation is given by two hydraulic rams as shown in Fig. 1.

The Canet recoil check is easy to adjust, any desired change in length of recoil being obtained by simply replacing the central counter rod by one of the required variation in diameter of cross-section.

HYDRO-PNEUMATIC RECOIL CHECKS.

Many forms of this type of recoil check have been devised and are now in use, principally for disappearing and high angle fire mounts, but the principle upon which all are constructed is the same and is well exemplified by Fig. 3, Plate XI, which is one of several forms of this type designed by M. Canet for disappearing mounts. A is the hydraulic recoil cylinder, and *a* the usual Canet central counter rod bolted to the head of the cylinder. When the gun recoils after firing, the excess of liquid in the cylinder A forces open the spring-loaded valve *a'*, and, passing through the pipes *b*, *b'*, takes against the face of the trunk pistons D, of the accumulators C, and compresses the air stored up in the compressed air chambers E. The valve a' is loaded to the pressure desired by means of the Belleville spring B.

When the recoil is completed the valve a' closes. To run the gun out the valve a' is opened by means of the hand wheel a'' on its stem, which permits the stored up compressed air energy to drive the liquid back and cause it to force the piston out and the gun up.

The form here illustrated has been found to work very satisfactorily. In general, when two recoil cylinders are used, each is connected with an accumulator placed between them, or else each cylinder contains its hydraulic chamber and accumulator within itself, as is the case with the VIII-inch howitzer described on page 151.

KRUPP'S HYDRAULIC RECOIL CHECK.

The type found in some modern Krupp mounts is one in which the piston head is solid, the recoil cylinders containing a number of rectilinear grooves of constant width but varying depth.

Another type now found in late Krupp naval turret mounts for heavy calibre guns is believed to be substantially as shown in section in Fig. 1, Pl. XIII. It will be noticed that the principal feature of this design is a modification of the Canet central counter rod.

In this type, as fitted to a turret mount, the piston rods AA are bolted to the upper carriage and move with the gun, while the stationary cylinders BB are rigidly secured to the underframe.

The piston rod A is hollowed out to contain a close-fitting, hollow cylindrical tube, *a*, which acts as a valve and is pressed by the loaded spring *b* against its valve seat, *c*, and which has an internal diameter sufficient to receive the central counter rod *d*. The piston head D, to which the valve seat *c* is screwed, contains four channels, *e*, which, when the tubular valve *a* is open, permit communication between the rear and front of the piston head. In the figure this check is shown with the gun run out for firing.

For simplicity of explanation we will describe the action in one cylinder only, that in each being identical.

Upon firing, the gun recoils with its upper carriage carrying the piston rod A with it. As the piston head D moves to the rear the pressure of the liquid in the cylinder forces the tubular valve *a* back against the pressure of its spring, *b*, thus opening communication through the channels *e* with the cylinder space to the rear of the piston head. Until the end of the recoil the action of the central counter rod *d* is similar to that described in the Canet recoil check, the cross-section of flowing liquid being proportional to the thickness of the rod, this thickness having been calculated for a constant pressure. The volume of space in front of the piston head is reduced by the space taken up by the entering piston rod, and the consequent surplus volume of liquid escapes through *f* and by the pipe *g* to the spring-loaded valve G,

PLATE XIII.

KRUPP'S HYDRAULIC RECOIL CHECK FOR TURRET MOUNTS.

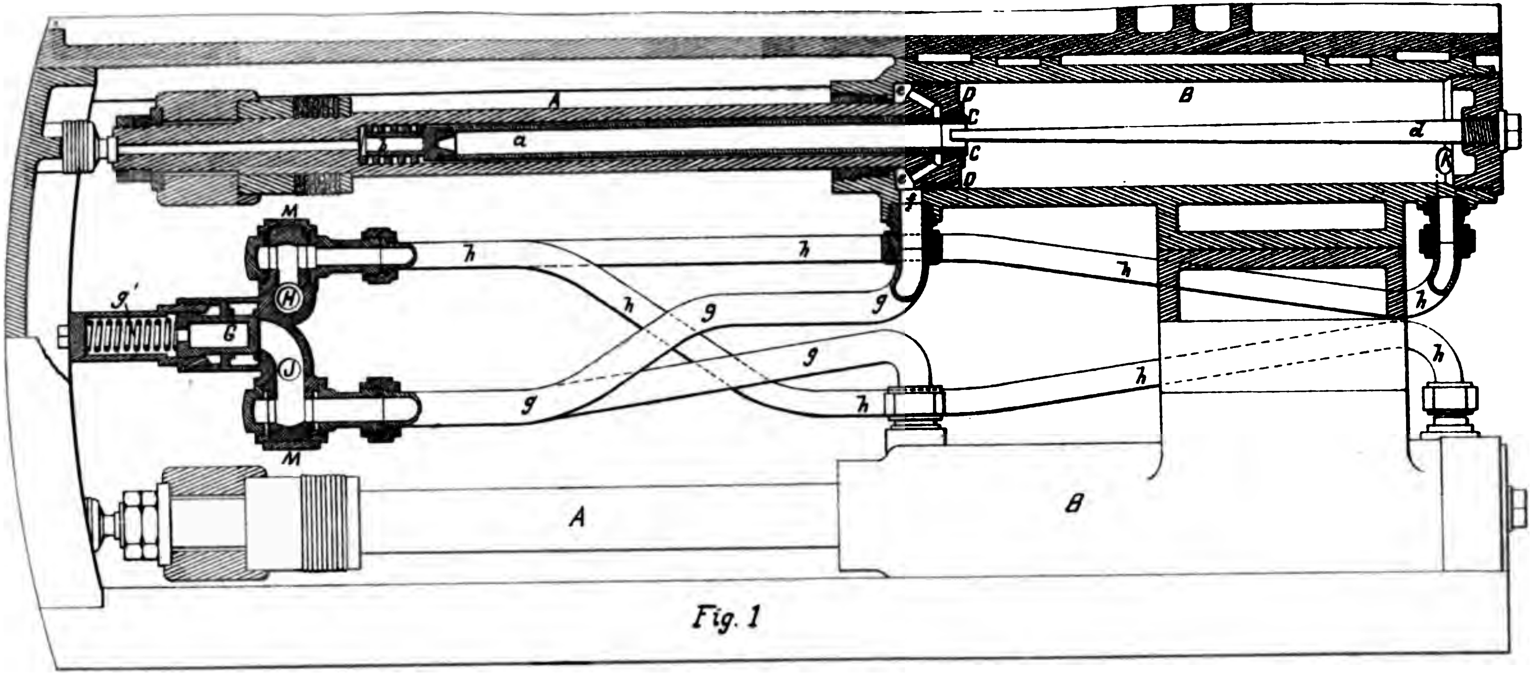


Fig. 1

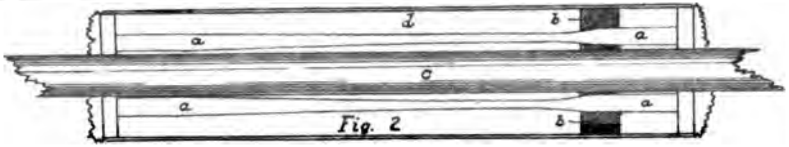


Fig. 2

SCHNEIDERS HYDRAULIC RECOIL CHECK

which it forces open and then passes down through an escape pipe (not shown) to the main exhaust of the turret hydraulic system. (In a check that is intended to be automatic this surplus liquid will go to an accumulator instead of being exhausted.) As soon as the recoil ends, the valve G closes by the pressure of its spring, *g'*.

To run the gun out, water under pressure from the main hydraulic system is admitted through a valve, H, and passing through the pipe *h* enters the rear end of the cylinder through the check valve K and forces the piston to the front, thus running the gun out.

The valve J is used to run the gun in when it is not desired to fire.

The pipes *gg* and *hh* are arranged to have a rotary motion about the trunnions, MM, to permit of training the gun in elevation.

Krupp has designed other types of recoil checks for different mounts which are now in use in foreign navies, but we believe the type here described in detail is his best for turret mounts.

SCHNEIDER'S HYDRAULIC RECOIL CHECK.

Fig. 2, Plate XIII, illustrates a very simple recoil check designed by M. Henri Schneider, of Creuzot, for some new broadside gravity return carriages which he has lately constructed for Spanish 5.5-inch naval guns.

The piston rod *c* is double, one end being rigidly attached to the front transom. The piston *b* is pierced with two circular apertures, through each one of which passes a longitudinal rod, *a a*, of varying-cross section. The cylinder *d* is secured to and moves with the upper carriage. The cross-sections of the rods *a a* vary in area in such a manner as to insure a practically constant pressure during recoil.

The reception trial of a carriage containing this check took place before a commission of Spanish royal artillery officers, and the results obtained were excellent.

Twelve shots in all were fired from a 15-centimetre 36-calibre gun, with a powder charge of 41.9 pounds of PB_3, and an initial velocity of about 2,083 f. s. Four shots were fired at level with projectiles weighing 88.2 pounds, with each of which the recoil was 22.56. Four shots were fired at an angle of + 5 degrees, with projectiles weighing 109.1 pounds, with each of which the recoil was 22.68 inches. Four shots were fired at an angle of + 24 degrees 30 minutes with projectiles weighing 109.1 pounds, with each of which the recoil was 22.44 inches.

FLEXIBLE HYDRAULIC RAMMER.

In some foreign vessels a flexible hydraulic rammer is used, principally with the object of economizing space.

One form of this rammer, the invention of Mr. O. Krell, director of the St. Petersburg Metallic Works, is illustrated in Figs. 3 and 4, Plate XII.

In this the rammer consists of a flexible rod working in a guide tube of any curvature and of a diameter equal to the calibre of the gun which it is intended to serve. This rod is composed of many short sections, one of which is shown at *a*, Fig. 3. The head of this section has six radial arms, at the end of each one of which is mounted a roller, *c*, Fig. 4. These rollers serve to guide the rammer in its travel in the guide tube *d*. The tail end of each section is formed into a ball, *b*, which is coupled to the head of the next lower one by a ball-and-socket joint.

THE WORKING OF TURRET GUNS.

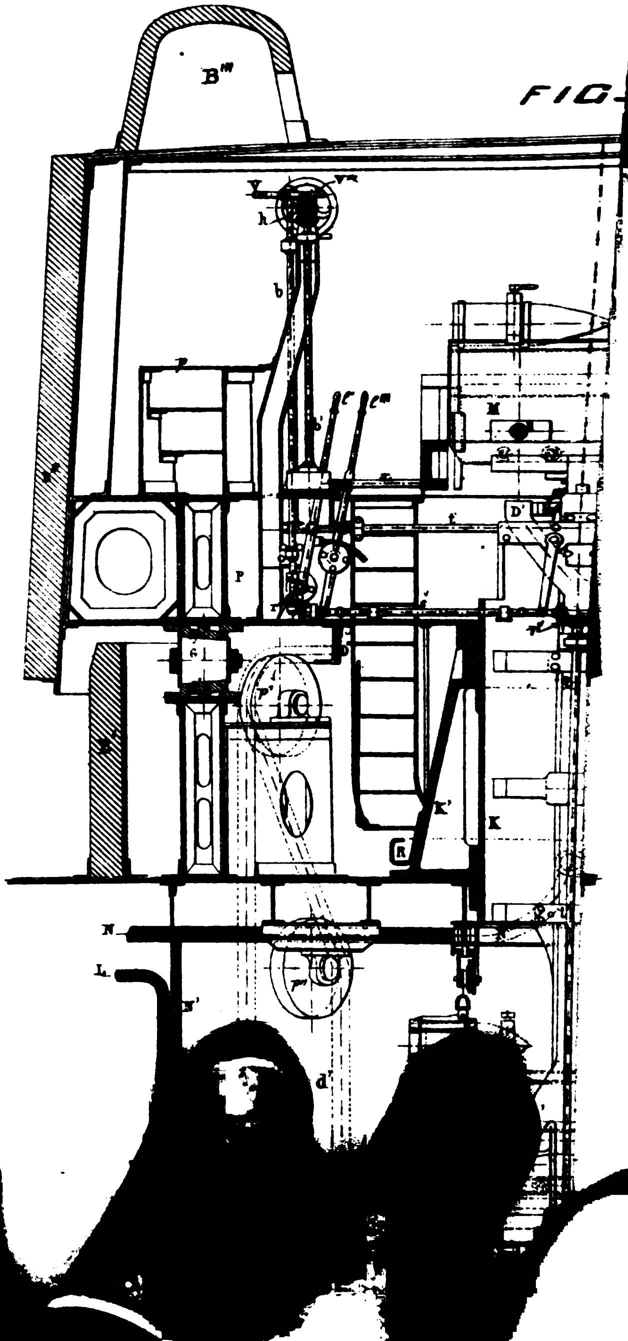
In order to give a clear idea of the general manner of handling ammunition for and of working heavy guns, we can do no better than to describe the principal details of a type of turret and mount designed by M. Canet, and adopted for the Spanish battle ship *Pelayo*, and for the French gun vessels of the *Ach éron* class. The sections shown in Figs. 1 and 2, Plate XIV, illustrate the essential parts.

Gun and mount.—Instead of trunnions the gun is furnished with trunnion bands which fit in corresponding gooves in the carriage of the mount and are secured in place by longitudinal rods, *a''*, Fig. 2, one on each side of the carriage which key in slots cut in the bands and grooves. The mount comprises a cradle or carriage, A, Fig. 2, which rests upon the slides of an underframe, B, to which it is held down by clips, *a a*. To the carriage and underframe are attached the cylinders, pistons, and ram necessary for taking up the recoil, running the gun in and out, and giving vertical train. The forward end of the underframe is pivoted at D, Fig. 1, to the trunnion bearings Q, one on each side, which bearings are rigidly secured to the turntable P. The piston rod of the elevating ram, O, Fig. 1, is jointed to a cross-piece on the lower part of the underframe.

The turntable, P, which is rigidly attached to the turret B'', rests at *c* on a series of live rollers, G G., which are fitted to revolve on a fixed circular track *c'* just within the upper surface of the fixed barbette B'. The sighting dome for the division officer, whose station is upon the sighting platform *p*, is at B.''' This turntable can be revolved in less than one minute.

Hydraulic power.—This, which revolves the turret, elevates and depresses the gun, hoists the ammunition, checks recoil, and returns gun to firing position, and—(with the larger guns of the *Pelayo*)—operates the loading mechanism, is obtained from a separate engine acting directly on differential double pumps, which compress the water to the desired pressure and then transmit it to the deck below through the main supply pipe L, from which it leads to perform the various operations enumerated, and is finally returned through the general exhaust pipe N.

FIG-



e main supply pipe L, after entering through the turret bulkhead connecting with the ammunition hoist valve T‴ by the connecting L′, Fig. 1, terminates in an articulated joint, J, from which leads a , *f*, to the turret training valve T′, Fig. 1. The joint J is connected wo similar joints, J′ and J″, all articulated so as to turn when platn is revolved, from the latter one of which the water is led through pipe *f′*, Fig. 2, to the valve box *g′*, Fig. 2, on the turntable, from ich three delivery pipes lead; one, *h′*, to the elevating valve T″, Fig. a second, *q*, Fig. 1, to the top of the piston of the ram O, upon which maintains a constant pressure; and the third, *y*, Fig. 2, to a slide lve, placed to the rear of the platform, for operating the two recoil ylinder pistons.

All exhausts above the turntable are led into the circular reservoir R, R, which encircles the base of the pivot K′ within which the turret revolves. This reservoir discharges through the general exhaust pipe N.

Ammunition hoist.—K is the pivoting tube of the turntable P, and K′ the pivot within which it revolves. To K are attached the guides D′ D‴, in which rollers, *n*, vertically guide the ammunition carrier M between the charging and loading positions, the base of the carrier being fitted to slide fore and aft on a platform forming the upper part of the telescopic hoisting cylinder.

To train in direction.—The division officer, from his station on the sighting platform *p*, Fig. 1, turns the wheel V with his right hand in the direction in which he wishes the turret to revolve, which results in transmitting motion by means of gearing at *r* and *r′*, and the rods *b* and *s* to the shaft *t*, at the lower end of which a pinion, *g*, Fig. 2, gears into the beveled wheel *a′*, revolving loosely around the hydraulic ammunition hoisting cylinder P′, Fig. 2; this wheel, through an arm *m*, keyed on the valve shaft *e*, Fig. 1, actuating the training valve T′, Fig. 1, to admit the water under pressure through the pipes *d″* and *d‴* to two horizontal cylinders, I and I′, the pistons of which travel in opposite directions, and give multiple motion to the two turret revolving chains *d* and *d′* which, passing over their guide pulleys *p′* and *p″*, take in opposite directions in the studs of the circular groovesD′ D″ of a drum in one with and under the turntable. The angular amount of train from the fore and aft line thus given is indicated to the division officer by the ter of a graduated dial attached to the hand wheel V.

e turret can be held in any position by screwing down on the hand V″, Fig. 2, which causes the turret to be clasped and held by the s *m′ m″*, Fig. 1.

some foreign battle ships provision is made for automatically stopthe turret in a safety position in case the officer in charge, while ing, should be suddenly disabled or killed.

train in elevation.—As the division officer turns the wheel V with ight hand he can also, with his left hand, give the necessary vertical train by means of the vertical hand wheel V''', Fig. 1. This, through the rods *b'* and *x*, operates the elevating slide valve T'', Fig. 2, which opens communication with the lower part of the elevating cylinder O, Fig. 1, either to admit water pressure through the pipe *q'*, Fig. 1, or to exhaust it through the pipe *e'*, thus causing either the elevation or depression of the mount which pivots around the trunnions D, Fig. 1, at the forward end of the under frame.

The angle of train thus obtained is indicated to the division officer on a graduated dial attached to the spindle *h* of the hand wheel V''', Fig. 1.

To load.—As the ammunition hoist is arranged to revolve with the turntable, loading can be performed in any position of the turret, but the gun must first be run out and laid level. The division officer brings the gun to a level by turning the hand wheel V''', Fig. 1, until the pointer on the dial showing the elevation marks *o*°, when the gun is temporarily locked in that position by two bolts, *v'* and *v''*, Fig. 2, the rods of which (only one is shown at *t'*) are connected by a crank to the lever I', Fig. 1, which is handled by one of the left-hand members of the gun's crew. Through the opening of the slide valve (not shown) near the rear of the platform, pressure is admitted to the recoil cylinders and the gun run out. In the mean time the ammunition carrier M having been charged, a hand stationed below, by actuating the lever *l''*, causes the valve T''' to admit pressure through the pipe S', Fig. 1, to the lower part of the telescopic ammunition hoisting cylinder P', the upper end of which is under constant pressure from the pipe *z*, which causes the three telescopic tubes *t''*, Fig. 2, to force up the ammunition carrier until the projectile is in line with the bore of the gun, in which position it is held by two bolts V^{iv} and V^{v}, which are bolted in for this and also for the two other positions necessary to load the half charges by means of the lever *l'''*, Fig. 1, operated by one of the right-hand members of the gun's crew.

When loaded the water is exhausted from under the cylinder P' through the exhaust pipe N', Fig. 1, which causes the ammunition carrier to sink to the charging position.

With guns of large calibre loading from the carrier is performed by hydraulic telescopic rammers.

To secure for sea.—Run the gun out to loading position and chock it. Then exhaust the water from under the elevating cylinder O. The turret is secured to the fixed barbette by means of the locking bolt *v*, which is screwed down into a corresponding slot in the barbette by means of the hand wheel V', Fig. 2.

All the work described above is done by hydraulic power, but many authorities believe that the question of rapidity of fire, in view of the very possible general introduction of smokeless powder, has become of such importance as to render advisable the substitution of electric for hydraulic power. It is understood that M. Canet has applied electricity to the working and training of turrets, the training, sighting, and firing of guns, and the handling of ammunition, in the new Chilian vessels lately built by the Societé des Forges et Chantiers de la Mediterranée.

SMALL-ARMS.

During the past year great activity has taken place in the manufacture of the small calibre magazine rifles referred to in No. IX. Russia has followed the example of the other principal European nations and adopted a small calibre magazine arm.

The new English magazine rifle has been criticised by the London Times and other English journals to an extent seldom equaled in the history of any military arm. A résumé of these criticisms does not properly come within the scope of this work, and we deem it only necessary to state that the construction of a limited number of a new model of this rifle, to be known as Mark II, has been authorized. If these prove successful on trial the Mark II will replace the first issue, now known as Mark I, described on page 128, No. IX. The principal points of difference are as follows:

(1) Magazine changed to a wider form to hold ten cartridges, and the stock modified accordingly.

(2) Bolt modified, the most important change being in the bolt head, which was originally attached to the bolt by a screw, but is now attached by a bayonet clutch.

(3) Locking bolt safety catch omitted and cocking piece strengthened.

(4) Extractor made stronger.

(5) Sights replaced by adjustable barleycorn foresight and open notch sliding rear sight.

(6) Slight modification of barrel and stock resulting in a decrease in weight of piece.

The following details concerning the manufacture of this weapon may prove of interest:

Number of component parts of rifle	98
Number of processes required in the manufacture	1,611
Number of workmen required to finish 1,000 rifles in 54 hours—6 working days of 9 hours each	1,310
Cost to the Government of a completed gun, about	$26.75

Much fault has been found with the manner of obtaining magazine fire from this weapon. It is a military axiom that a soldier should always be ready to fire, and one of the principal objects of a magazine rifle is to enable the soldier to be prepared to fire at any time with the least delay. With fixed magazines and temporary chargers of cartridges, such as those designed for the Belgian Mauser, rapidity of fire will reach a maximum; but this is not the object sought with the English rifle, for after the British soldier has emptied his magazine, it will be found that the introduction of cartridges into the magazine, one by one, and the after feeding them to the gun, will reduce his rate of fire so much, after the first few moments, as to bring it down to even less than that possible with a single loader, and, in addition, he will not always be ready to fire. In reality the gun is designed to be used as a single loader until an emergency arises which will require a great rapidity of fire up to ten shots.

The effective range of the modern magazine rifle is not less than a mile, and the maximum range not much short of 2 miles. There is danger from ricochet up to a range of nearly a mile.

The Chinese are still seeking for a small-bore magazine arm, and it is thought that one will be adopted having a fixed magazine and embodying the best points of several of the new European arms.

The number of the new Krag-Jörgensen magazine rifles necessary to fully arm the Danish infantry is to be finished by December 31, 1892.

Holland has transformed the Beaumont into a magazine rifle by applying to it the Vitali fixed magazine, and will continue to use this transformed weapon until a satisfactory small-bore arm can be found.

The Italian military authorities have decided upon a new magazine small arm of a calibre of .256 inches, which is to combine the best features found in the new European rifles. This decision was reached after exhaustive experiments with a number of magazine rifles of this calibre of domestic design and manufacture. This new gun weighs 8.2 lbs.; will have a fixed magazine containing 5 cartridges; and is intended to use a smokeless powder charge that will develope an initial velocity of about 2,300 f. s.

The money has been appropriated to commence the manufacture at once, and the rifle will have the smallest bore of any yet adopted abroad.

The Russian Government has adopted the new magazine rifle referred to on page 125, No. IX. After very satisfactory proof trials, an order has been placed with a French factory for 3,000,000.

It is reported that this will have a fixed under-box magazine, and will be of .30 inches calibre.

In Spain a Government Commission has experimented with sixty different models of small calibre magazine rifles, of which number twenty have been retained for more extended trials. Of these it is understood that the one which proves most satisfactory to the Commission will be adopted for use in the Spanish army.

Reports have been frequent to the effect that the Germans have had serious trouble with their new infantry rifle, the breech-bolt not having proved strong enough to withstand the action of the German small-arm smokeless powder. It may be that the powder used was adopted before its quality was proved by proper experiments, and that the pressures obtained were unnecessarily high, but, at any rate, it has been found necessary to so modify the bolt as to enable it to withstand greater pressures than were at first anticipated.

It is also stated that the metal mantlet over the barrel, with its intervening cushion of air, does not remedy the progressive heating of the barrel, but, on the contrary, serves to rapidly increase the temperature; soon rendering the gun too hot to hold, causing an unequal expansion of barrel and mantlet, and injuring the rifling. In this and all other fixed magazine rifles rapidity of fire is in proportion to the physical endurance of the soldier. In continuous rapid firing not more than twenty-five shots can be fired, using smokeless powder, before the gun will heat to such an extent as to render it necessary to stop firing.

Interesting experiments carried out in France give a good idea of the rapidity of fire possible with magazine arms. Ten soldiers were selected to fire with maximum rapidity at a target 984 feet distant, representing fifteen men standing a few inches apart.

These soldiers selected a kneeling position for firing, and each had a companion standing near him to supply him with another rifle as soon as the one he was using heated to such a degree as to be unfit for use. The hits averaged only 8.6 per cent. The rifles all heated between the twentieth and twenty-fifth shots, and new ones were immediately handed to the men. The soldiers were compelled, from physical exhaustion alone, to cease firing at the end of a time averaging 10 minutes for the entire party, during which the average of shots per man for the entire party was 154.2.

The following table contains some of the principal features of the modern small arms adopted by foreign nations:

Nation.	Calibre.	Weight.	Name or type.	Type of magazine.	Number of cartridges in magazine.	Number of rounds carried per man.	Arranged to cut off or not.
	Inches	*Pounds.*					
Argentine Republic.	.301	8.6	Mauser	Vertical fixed under-box	5	....	Yes.
Austria	.315	9.68	Mannlicher	....do	5	140	No.
Belgium	.301	8.6	Mauser	....do	5	....	Yes.
Bulgaria	.315	9.68	Mannlicher	....do	5	....	No.
Chili	.315	9.68	Mannlicher	....do	5	....	No.
Denmark	.315	9.4	Krag-Jörgensen	Horizontal fixed under-box	5	120	Yes.
England	.303	9.1	Lee-Speed	Vertical detachable under-box.	8 10	112	Yes.
France	.315	9.2	Lebel	Fixed under tubular	8	112	Yes.
Germany	.311	8.4	Mannlicher	Vertical fixed under-box	5	150	No.
Holland	.433	10.0	Beaumont-Vitali	....do	4	98	Yes.
Italy	.405	9.5	Vetterli-Vitali	....do	4	100	Yes.
	.256	8.2	....	....do	5	....	
Russia	.300	....	....	....do	....	....	
Siam	.315	9.68	Mannlicher	....do	5	....	No.
Sweden	.315	8.8	Remington	Single-loader	....	100	
Switzerland	.295	9.48	Schmidt	Vertical fixed under-box	12	....	Yes.

BELGIUM (Mauser, M/89, CALIBRE, .301).

This rifle, which was briefly referred to on page 126, No. IX, is illustrated in Plate xv.

The magazine A, Fig. 1, is held in place by the spring catch *a*, and can be withdrawn from below when pressure upon the catch knob *a′* releases it from the spring catch. The cartridges, five in number, are contained in the charger B, Figs. 4, 5, and 6, and are loaded into the magazine from above. The charger is a metal frame with projecting flanges, Fig. 6, fitted to take in the grooves at the rear ends of the cartridges. Into these flanges the bases of the cartridges are pushed, and when in are pressed outward, and thus held by a spring, Fig. 5. A light pressure of the finger is sufficient to push the cartridges out of the charger into the magazine. It is not intended that the magazine shall be removed except for cleaning or repairs. Cartridges can be inserted in the magazine from the chargers, or one at a time by hand.

The bolt C, Fig. 1, is a hollow steel cylinder having a lever, *c*, at its rear end and two locking lugs on opposite sides of its front end. When the bolt is pressed home and turned through an arc of 90°, these lugs take in the recesses *c′ c′*, Fig. 1, and lock the bolt. After firing, when the bolt is turned and drawn to the rear, these locking lugs travel in corresponding grooves in the breech casing. The extractor *d*, Fig. 1, fits in a groove in the upper surface of the bolt. After firing, as the handle of the bolt is rotated, it moves to the rear slightly along an incline on the body, thus causing the extractor to withdraw the empty cartridge case nearly one-eighth inch before the bolt is drawn to the rear.

Cartridge ejector.—The empty cartridge case is drawn to the rear by the extractor until near the end of the bolt's travel, when the left side of its base takes against the nose *e*, Fig. 2, of the cartridge ejector E, which, with the continued motion of the bolt to the rear, results in smartly throwing the empty cartridge case out to the opposite side. This ejector is pivoted to a lug, F, on the left side of the breech casing and is pressed against the bolt by the spring *e′*, the bolt being recessed near its front end to permit the nose *e* to be pressed in sufficiently to take against the base of the empty cartridge case.

Bolt stop.—On the lug F is also pivoted the bolt stop G, Figs. 2 and 3, which consists of an arm having a rib, *g*, projecting through an opening in the side of the breech casing, and fitting in the path of the left locking lug on the front end of the bolt in such a manner as to arrest the rearward movement of the bolt when the locking lug brings up against it. This bolt stop is in the form of a frame which encloses the lug F, to which it is pivoted, by a vertical pin. The outer side of this frame is closed by a flat spring plate, *h*, secured to the outer end of the arm of the bolt stop, and pressing down at its front end on the rib *g*. By pulling the bolt stop up around its pivot the rib *g* will be withdrawn from the part of the locking lug, permitting the withdrawal of

PLATE XV.

BELGIAN MAUSER MAG. RIFLE, M. 1889

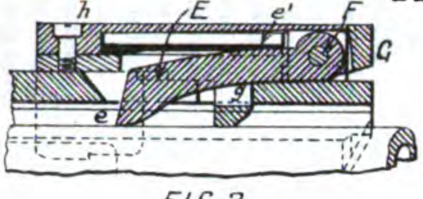


FIG. 2

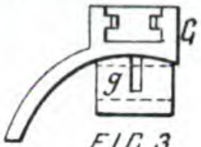


FIG. 3

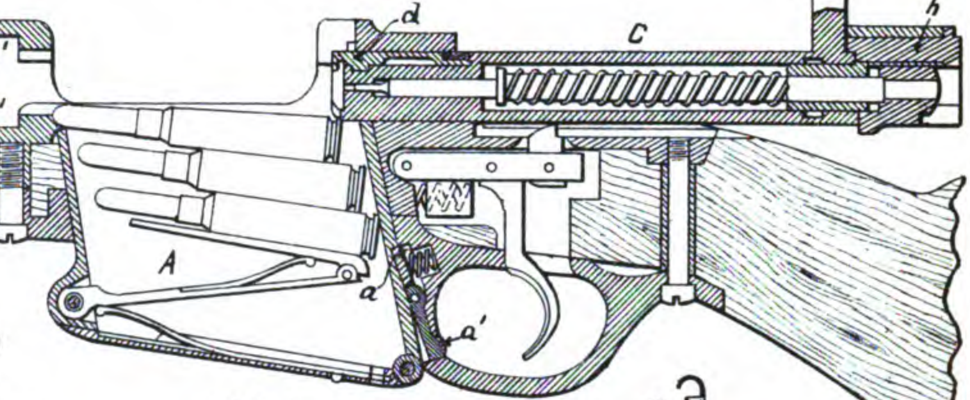


FIG. 1

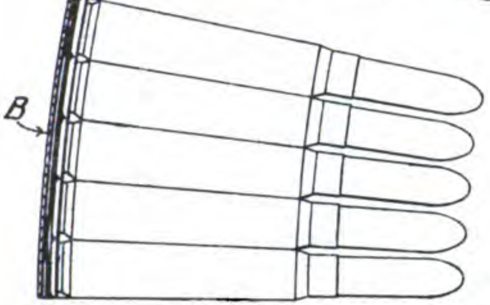


FIG. 4

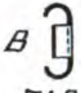


FIG. 6

FIG. 5

the entire bolt from its casing, all parts of which can then be taken apart with ease.

The firing mechanism is clearly seen in Fig. 1. The firing spring is noticeable in being unusually strong on account of the use of smokeless powders.

The locking catch *h*, Fig. 1, is a short longitudinal plug with a cam at each end, which, by means of a thumb piece can be turned so as to cause the front cam to take in a recess on the end of the bolt so as to keep it from turning, while the rear cam places itself in front of a nut on the end of the firing pin and holds it fast.

This weapon, which has been adopted by Belgium, Turkey, and the Argentine Republic, fulfills many of the requirements of a perfect magazine arm. Its advantages over the English rifle are too manifest to require comment. Unlike the German and Austrian Mannlichers, which can only be used as single loaders when their magazines are empty, this rifle can be so used at any time whether its magazine be full, partly full, or empty, in consequence of which it can be used either as a magazine arm or single loader at will. It will permit of a little greater rapidity of fire as its charger is not introduced into the magazine.

An initial velocity of 1,981 f. s. has been obtained with a chamber pressure of but 7.4 tons to the square inch. The twist of its rifling is one turn in 9.8 inches.

DENMARK (Krag-Jörgensen, calibre .315).

This rifle, which was briefly referred to on page 127, No. IX, is illustrated in Plates XVI and XVII.

Breech mechanism.—The bolt, Figs. 2 and 3, is a cylindrical tube fitted to slide horizontally in the receiver. The front end is in one with the tube and is pierced with an axial vent for the firing pin of the form shown at *a*, Fig. 3. One side projects to form a locking lug, *b*, Figs. 2 and 3, which, when the bolt is pressed home and turned down 90 degrees to the right, enters the recess *c*, Fig. 2, in the forward part of the receiver and locks the bolt. The movement of rotation of the bolt is limited by a longitudinal rib on its right side.

The rear end of the bolt terminates in a handle at right angles to its length and is recessed as shown at *d*, Figs. 2 and 3, the wall in this recess formed by the handle being straight while the left hand is curved laterally. From the handle a locking shoulder extends nearly one-third around the bolt on top, from right to left.

The receiver A, Fig. 2, is fitted to take the bolt and magazine. At its upper forward end B, Fig. 1, is a recess, *e*, Fig. 2, into which, when the bolt is forced home, the claw E, Fig. 3, of the extractor enters. The rear lug of the receiver O, Fig. 1, serves to guide the bolt and to limit its movement to the rear, and has a groove, *f*, Fig. 11, on top in which the bolt carrier slides. The plane of the rear face of this lug inclines to the rear from its base to its upper edge, and at its rear is a recess, *g*, Fig. 1, into which the bolt handle fits when it is turned down to the firing position.

Firing mechanism.—The firing pin, Figs. 2 and 3, is in two parts connected by a ball-and-socket joint and extending through the bolt as shown in Fig. 3. The front part is shown in Fig. 5. The half and full cock lugs are at *h*, *h′*, Fig. 3.

The extractor D, Fig. 3, is jointed to the bolt carrier at its rear end *i*, Fig. 3, its claw E having its upper and lower edges beveled to permit it to force its way over the rim of the cartridge case and to also take in the recess *c* in the forward lug of the receiver.

The cartridge ejector.—Two ejectors are shown, either one of which may have been permanently adopted by this time. One, shown in Fig. 6, is pivoted in a recess in the left side of the receiver, its head, *k*, lying flush with the surface of the receiver, and its heel, *k′*, projecting into the receiver. The movement of the bolt presses the heel down and head up, the latter working in the curved score F, Fig. 4, of the bolt.

The second form of cartridge ejector is shown in Fig. 3. The locking lug *b* has a chambered hole containing an ejecting pin, G, which, when the bolt reaches the limit of its movement to the rear, is struck by a projection, X, Fig. 11, on the rear lug C and caused to take against the base of the cartridge case and throw it out to the left.

The magazine.—Figs. 1, 7, 8, 9, and 11, show an open case screwed in the receiver. It has a flat bottom, *l*, Fig. 8, with its inner wall curving upward. The front is closed by a door, G, Figs. 1 and 7, which, when closed, is held in position by the spring latch *m*, Fig. 7, which is arranged to catch in a locking notch, *n*, and is released by pushing its thumb piece, D, to the right. This door is pivoted to the magazine by a screw, *o*, Fig. 7, and in its inner face has an opening in which is seated the heel *p*, Fig. 8, of a strong spring, I, the curved inner arm of which, *p′*, takes in a concave score, *q*, Fig. 8, of the carrier plate lever L. The other extremity of the lever L is in the form of a scoop, L′, Figs. 7, 8, and 9, to which is attached a moveable carrier plate, M, in such a manner as to maintain its entire length against the cartridge in front of it until all the cartridges are fed to the gun. The bearing surface of the carrier plate is curved to the form of the cartridge M, Fig. 11, while its back, at the after end, is so scored as to wholly receive the lever L when the magazine is charged with cartridges and its gate closed. The magazine is filled from a charger containing five cartridges, lying side by side, held in place by two arms in such a manner that when the rod containing the arms is turned one arm is moved clear of the inner cartridge and the other arm forces them into the magazine.

To use the piece, supposing it cocked preparatory to firing.—Pull the trigger and the sear *r*, Fig. 2, will release the cocking lug *h*, Fig. 3, the tension of its spring then drawing the firing pin forward and discharging the piece. Turn the bolt handle up, and as the bolt turns its curved wall in the recess *d*, Fig. 3, will act on the front end of the arm N, Fig.

DANISH MAGAZINE RIFLE
KRAG-JORGENSEN

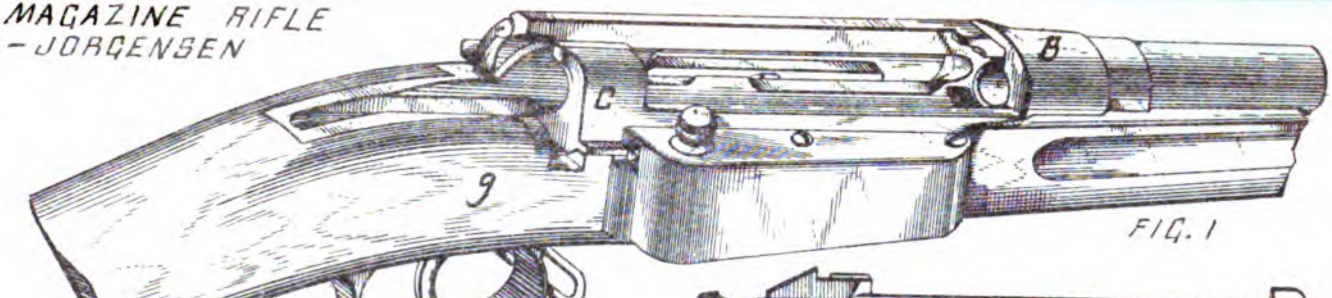


FIG. 1

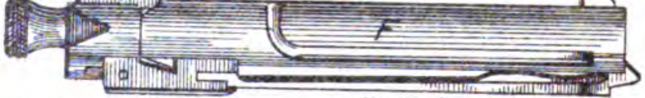


FIG. 4

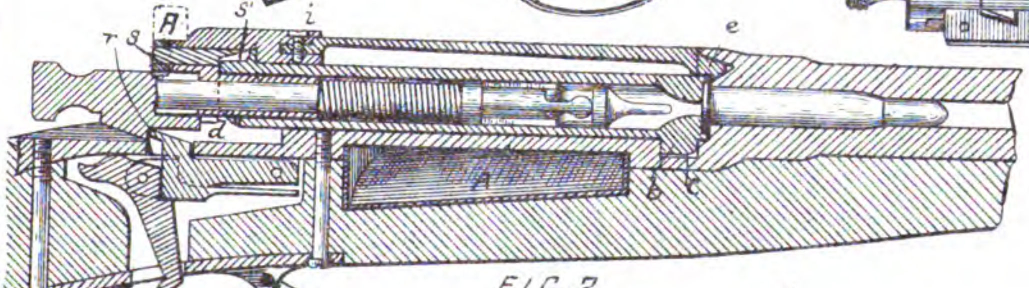


FIG. 2

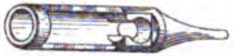


FIG. 5

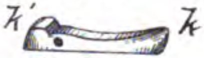


FIG. 6

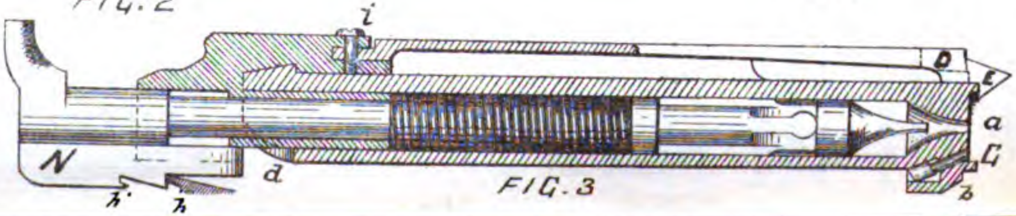


FIG. 3

DANISH MAGAZINE RIFLE, KRAG-JORGENSEN

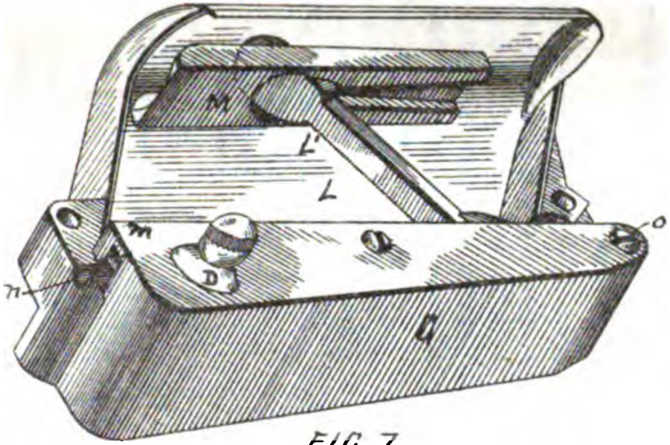


FIG. 7

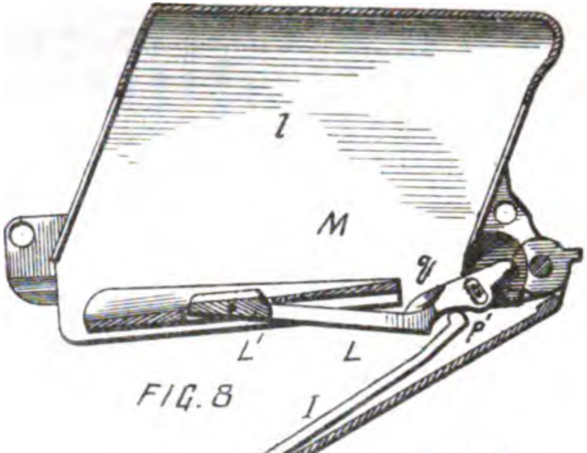


FIG. 8

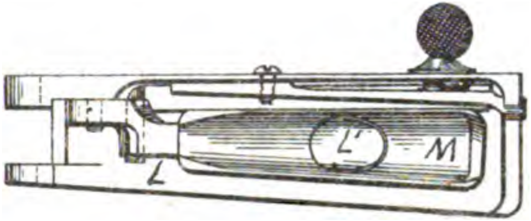


FIG. 9

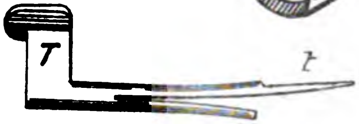


FIG. 10

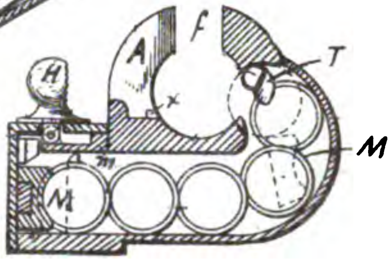


FIG. 11

3, to force the firing pin to the rear against the pressure of its spring until the straight wall takes against the arm N, and locks the firing pin. This upward movement of the bolt handle along the rearwardly-inclined face of the lug C, Fig. 1, unlocks the bolt by removing the handle from its recess, *g*, Fig. 1, and the locking lug *b* from its recess, *c*, Fig. 2, and, owing to the inclination of the rear face of the lug, causes a small movement of the entire bolt to the rear, which results in slightly starting the empty cartridge case from its seat in the bore. Draw the bolt to the rear and the extractor will withdraw the empty cartridge case until the ejector used acts to throw it out smartly to the right side.

To lock the piece.—The piece must be at full cock. Turn the lug R, Fig. 2, up, and the rounded portion of its locking pin S, Fig. 2, will enter a semi-cylindrical recess, S′, in the breech bolt and lock it against any turning movement.

To use the piece as a single loader.—A lever, Fig. 10, with a split arm, fits in a recess in the rear end of the receiver, being retained therein by the pressure exerted by its arms *t* and *t′*. It is operated by its thumb lug T, Figs. 1, 10, and 11, in such a manner that when the lug is turned up the long arm *t*, Fig. 10, partially closes the opening from the magazine, Fig. 11, and shuts off the supply of cartridges. The gun can then be fed by hand.

With the new Danish smokeless powder manufactured for use in this rifle, a charge of 33.9 grains has imparted an initial velocity of 1,968 f. s. to a bullet weighing 237.6 grains with a corresponding chamber pressure of 16.4 tons per square inch.

HOLLAND (Beaumont-Vitali, M/71-88).

The Government has transformed its infantry rifle—the Beaumont, M/71, calibre .433, into a magazine arm by the addition of the Vitali magazine. This has necessitated some changes, principally in the bolt, the extractor, and the firing mechanism. A cut-off has been fitted to permit of either magazine or single fire.

The magazine is filled from above either by hand or by means of chargers containing 4 cartridges. Each soldier is to carry 94 rounds on his person and 4 in the magazine.

The following are the principal details of this rifle:

Length without bayonet	inches	52
Length with bayonet	do	72
Weight without bayonet	pounds	9.97
Weight with bayonet	do	10.8
Weight of complete cartridge	grains	663.5
Cost of transformation, per gun		$3.33

ITALY (Vetterli-Vitali, M/70-87).

The Government has transformed its infantry rifle—the Vetterli, M/70—to a magazine arm by the addition of the Vitali magazine fitted to hold 4 cartridges; 1,500,000 rifles have been thus transformed up to the present time.

The piece was modified to permit the insertion of this fixed magazine, and a cut-off fitted to allow of either single or magazine fire. The magazine is filled from above by hand or by means of chargers containing 4 rounds. Each soldier is to carry 96 rounds on his person and 4 in the magazine.

The following are the principal details of this rifle:

Calibre	inches	.405
Length without bayonet	do	53.2
Length with bayonet	do	73.6
Weight without bayonet	pounds	9.48
Weight with bayonet	do	10.76
Charge of smokeless powder, ballistite	grains	37
Weight of brass-enveloped bullet	do	246.9
Weight of complete cartridge	do	447.5
Muzzle velocity	f. s.	2,017

A new small bore magazine rifle, of .256 calibre, has been officially adopted during the last month and its manufacture commenced.

SWEDEN (Remington—Transformed, M /67-89).

The Swedish-Norwegian Commission has adopted a single loader small arm for Sweden of a calibre of .315 inches.

The rifle is the old Swedish Remington transformed, the Remington system of breech closure having been retained with some necessary modifications, principally in the direction of greater strength.

Following are the principal details:

Calibre	inches	.315
Length without bayonet	do	49
Length with bayonet	do	68.1
Weight without bayonet	pounds	8.82
Weight with bayonet	do	9.59
Rifling:		
Length	inches	33
Number of grooves		6
Twist—one turn in	inches	11.34
Length of complete cartridge	do	3.03
Weight of bullet	grains	231.45
Black compressed powder charge	do	72.52
Corresponding muzzle velocity	f. s.	1,755
Corresponding chamber pressure	tons to sq. in.	12.5
Grakrut (smokeless powder charge)	grains	48.6
Corresponding muzzle velocity	f. s.	1,965
Corresponding chamber pressure	tons to sq. in.	14.7

SWITZERLAND (Swiss Magazine Rifle, Model 1889, Calibre .295).

This rifle, the invention of Colonel Schmidt, director of the Berne Small Arms Factory, is illustrated in Plate XVIII.

The Government has ordered 150,000, for which 45,000,000 cartridges are to be manufactured. The barrel has a wooden guard extending almost to the muzzle.

Breech mechanism (Fig. 2).—This comprises a bolt, *a*, a sleeve, *b*, and

PLATE XVIII.

SWISS MAGAZINE RIFLE, M. 1889

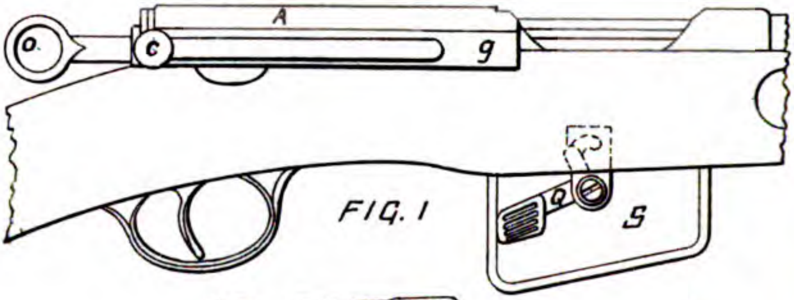
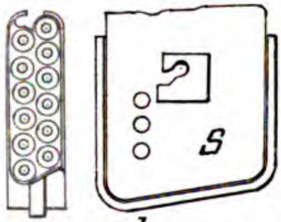


FIG. 1



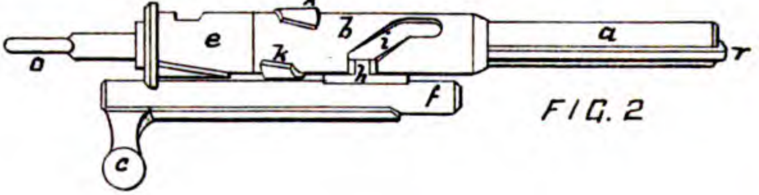


FIG. 2

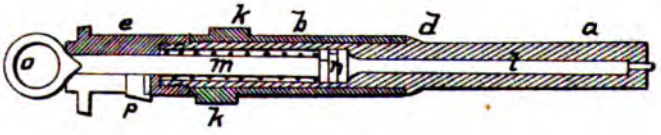


FIG. 3

a bolt handle, *c*, the sleeve being held against the shoulder, *d*, by a block, *e*, screwed to the end of the bolt, and all these parts enclosed within a breech casing, A, Fig. 1. The bolt handle, *c*, has a projecting cylindrical tongue, *f*, fitting in a tube, *g*, Fig. 1, and also a lug, *h*, which projects through a groove, *i*, and to the interior of the bolt. This groove, which is in the sleeve, is of the form shown in Fig. 2. On the outer surface of the sleeve are two curved locking lugs, *k k*, of the form shown in Fig. 2, fitted to work through curved inclined grooves in the inner surface of the casing to the locking position.

The firing pin, Fig. 3, is in two parts, a striker, *l*, and a rod, *m*, connected by means of the coupling, *n*. The rod terminates in a ring, *o*, and has a projecting firing lug, *p*, fitted to work in a channel in the block, *e*. The firing pin spring takes against the after face of the coupling, *n*, and the forward face of the block *e*.

The magazine, *s*, Fig. 1, is of tinned sheet-iron fitted to hold 12 cartridges, arranged in two vertical columns in such a manner that the cartridges half ride each other. It is inserted in an opening in the body from underneath in front of the trigger-guard, and is held in place by means of a double arm lever bolt, Q, Fig. 1, placed on the right side of the magazine and pivoting around an axis on the guard-plate. By pushing on this lever the magazine can be made to take either one of two positions by means of a tenon on the small arm of the lever fitted to slide in a groove riveted on the side face of the magazine. When the magazine is in the upper position of the two, the gun must be used as a magazine arm, and when in the lower position, as a single-fire arm. The magazine is filled from the top by means of chargers containing 6 cartridges each. When the magazine is filled a thirteenth cartridge can be placed in the bore before the breech is closed. The sight, which is graduated in 100-metre lengths from 300 meters to 2,000 metres, simply consists of a hinged flap with a sliding bar, the latter being held at the desired graduation by means of a strong spring.

To use the piece.—Immediately after firing the firing-pin will be found in the position shown in Fig. 3. Draw the bolt handle directly to the rear and the motion of the lug, *h*, in the groove, *i*, will cause the sleeve, *b*, to rotate and free the locking-lugs *k k* from their locking position in the casing. At the same time the extractor, *r*, Fig. 2, starts the empty cartridge case from the bore. The bolt handle is then continued directly to the rear until its motion is arrested by a spring stop, shortly before which the empty cartridge case is thrown out by an ejector fitted within the breech casing. During this movement of the bolt to the rear the lug *h* takes against the projection of the striker *l*, and forces the firing-pin back against its spring until the lug *h* reaches the position shown in Fig. 2, when it takes in a safety notch and holds the firing-pin in the cocking position as the bolt is entirely withdrawn. In this position a cartridge is forced up from the magazine, and as the bolt is pushed to the front, is forced into the bore with the extractor claw taking over its rim. During the forward movement of the bolt handle the firing-lug *p*, Fig. 3, takes against the trigger point and holds the firing-pin compressed against its spring. When within a short distance of the closed position the lug *h* causes the sleeve to rotate and its locking-lugs, *k k*, enter the locking recess as the bolt closes.

To lock the piece.—See that the piece is cocked and then turn the ring *o* to the left to a horizontal position, when the firing-lug will take in a groove in the block *e*, which will prevent any forward movement of the firing-pin.

The following details are believed to be accurate:

Calibre	inches..	.2
Cost		$16.
Weight without bayonet	pounds..	9.
Rifling:		
Number of grooves		3
Depth of grooves	inches..	.0
Width of grooves	do..	.15
Twist, one turn in	do..	10.6
Weight of powder (P. C./88) charge	grains..	29.3
Weight of bullet	do.	215.6
Length of bullet	inches..	1.1
Weight of complete cartridge	grains..	401.2
Length of complete cartridge	inches..	3.0
Cost of complete cartridge	cents..	1.9
Number contained in magazine		[illegible]
Initial velocity, about	f. s..	2,0
Chamber pressure	tons to square inch..	14.4
Extreme range	yards..	3,2

SMOKELESS POWDERS.

The details of trials of the most noted smokeless powders are insufficient to show in what degree the ballistical formulæ of ordinary powders will have to be modified in order to enable us to represent the action of the smokeless ones now in use in foreign countries, but an approximate idea of the relative values of some of these may be obtained from a comparison of the work done by projectiles, in guns of the same calibre, with charges giving equal chamber pressures. Such comparisons would be exact if the weight of projectile, density of loading, and the length of travel of the projectile were identical, but up to the present no such conditions have obtained.

For comparisons with nearly equal pressures we are limited to results obtained in trials carried out by Krupp, Canet, and Schneider, some of which are tabulated below. The BN referred to is not believed to be as powerful as the French Government product—Poudre B.

Gun used.	Smokeless powder.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Chamber pressure (tons per square inch).	Muzzle energy.	Energy per pound of powder.
		Pounds.	*Pounds.*	*f. s.*		*f. t.*	
Krupp, 15^{cm}, 35 calibre, B. L. R.	Nobel, c/89.	16.3	112.45	1,945	14.1	2,949	1
Canet, 15^{cm}, 36 calibre, B. L. R...	BN	26.4	93.9	2,270	14.1	3,354	1

PLATE XIX.

SMOKELESS POWDER, BALISTITE

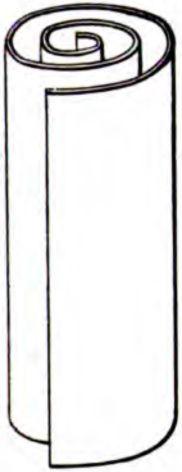


FIG. 1

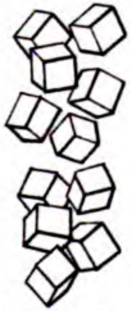


FIG. 2

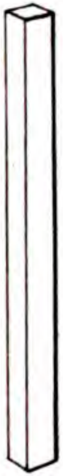


FIG. 3

Here the comparison is in favor of the C/89 and this would be more pronounced if the weights of projectiles and their lengths of travel had been the same.

Another comparison is afforded by trials with a Schneider 15 centimetre gun as follows:

Gun used.	Smokeless powder.	Weight of charge.	Weight of projectile.	Muzzle velocity.	Chamber pressure (tons per square inch).	Muzzle energy.	Energy per pound of powder.
		Pounds	*Pounds.*	*f. s.*		*f. t.*	
Krupp 15^{cm}, 35 calibre, B. L. R..	Nobel, c/89	16.1	112.45	1,939	13.6	2,932	182
Schneider 15^{cm}, 36 calibre, B.L.R.	BN	28.7	88.2	2,325	13.7	3,305	115

In each of these cases we see that, per weight of charge, the C/89 does much more work than the BN. The C/89 used in each case was from the same lot, but the BN. was from separate lots.

It is reported that the Nobel and BN. powders have been perfected for naval use, but as yet it is impossible to make any definite statement as to their keeping qualities under varying climatic conditions.

With these powders a small igniting charge of rifle powder is frequently used.

Experiments thus far made have demonstrated that with short guns the ballistical effects of smokeless powders are not greater than those of ordinary powders.

Although for equal muzzle velocities the weight of ballistite, C/89, BN., or cordite required is less than one-half of that of ordinary powders, the size of cartridge required for each is about the same, this being due to the lighter specific gravity of the smokeless powders and the greater difficulty found in packing them compactly.

The Nobel powder, adopted in Italy, ballistite, and described on page 115, No. IX, is illustrated in Plate XIX, where Fig. 1 shows the sheet into which it is first rolled, and from which small grains for rifle powder are obtained by cutting it lengthwise into strips and then into small grains of cubical or other shapes. Fig. 2 shows cubes obtained from sheets of a thickness equal to the size of cube and which are intended for use in small calibre rapid-fire guns. Fig. 3 is a strip of a square cross-section cut from a sheet of the same thickness, a number of which, when put up in bundles, are to be used as cartridges for high-power, and the larger calibres of rapid-fire guns.

That the Italians are satisfied with the results of their experiments with this powder is made evident by the fact that, up to the present time, they have accepted over 1,000,000 pounds for service use, and have adopted and introduced it in the land service for field and mountain guns.

Mr. Nobel also proposes to use his powder in the form of tubes, hollow caps, and scrolls. To form the last named, he rolls the first prepared sheets with projecting ribs, which, either plain or perforated wi holes to increase inflaming surface, are to be rolled up into cylindri scrolls to just fit into the cartridge cases to be used.

Hundreds of smokeless powders have been invented, but we can o refer to those which have given promising results under trial.

'The Schwab smokeless powder referred to on page 120, No. IX, now being used in Austria. Its use in the Austrian Mannlicher mag zine rifle has necessitated a change in the graduations of the sight ba to correspond with the greater ranges obtained with it.

A new smokeless powder is now being manufactured in Denmark f use in the Krag-Jörgensen rifle. It is reported to give off but lit smoke, and to emit a slight odor.

After firing one hundred and twenty cartridges containing this po der from a Krag-Jörgensen rifle, the temperature of the weapon w found to be 245 degrees, and after firing the same number of cartrid containing ordinary powder, under similar conditions, the temperat of the weapon was found to be 267 degrees.

BN. POWDERS.

The Hotchkiss Company has lately conducted, at its French fa tory, an extensive and interesting series of experiments with sampl of this powder, during one set of which, in trying for similar pressur with this and ordinary powders, using service projectiles, the followi interesting results were obtained from rapid-fire guns:

[Hotchkiss rapid-fire gun used.]

	Powder.	Weight of charge.	Muzzle velocity.	Chambe pressur (tons per square inch).
		Pounds.	*f. s.*	
3.94-inch, 33-pounder	Smokeless	6.8	2,215	15
	Ordinary	13.2	1,903	15
3.00-inch, 15-pounder	Smokeless	4.0	2,411	14
	Ordinary	6.6	2,067	14
2.56-inch, 9-pounder	Smokeless	1.87	2,231	16
	Ordinary	3.63	2,034	16
2.24-inch, 6-pounder	Smokeless	1.04	2,132	16
	Ordinary	2.04	1,968	16
1.85-inch, 3-pounder	Smokeless	0.93	2,302	15
	Ordinary	1.7	2,001	14
1.46-inch, 1-pounder (long)	Smokeless	0.13	1,667	6
	Ordinary	0.18	1,427	7

CORDITE.

In October last extensive experiments were carried out by the ag- lish War Office Chemical Committee on Explosives to determir he liability of this smokeless powder to explode *en masse*.

The following details are taken from the Fifteenth Annual Report of Her Majesty's Inspector of Explosives:

(1) 100 pounds of coarse cordite (3 inches diameter and 14 inches in length) packed in a service box (measuring 2 feet 3 inches by 14 feet 6 inches by 7 feet 9 inches deep, and having 1¼-inch sides and 1-inch top and bottom) was attempted to be ignited by means of a tube and small priming charge of gun cotton. But the cordite failed to ignite.

(2) Repetition of above, but using a small priming charge of fine cordite (0.05 inches diameter and 11 inches long). The whole mass burst immediately into flame and burned with great and rapid energy and brilliancy. The lid was removed by the energy of the outburst, the screws being drawn and those on one end bent. The mass burned for about 3 seconds, and the light was of a most brilliant character.

(3) Repetition of No. 1, and with same results. No ignition.

(4) Repetition of No. 2. The cordite ignited and burned with great brilliancy and a gush of bright flame for about 7¼ seconds. The lid of the box was forced off (as No. 2), and the screws were drawn, and in some cases bent.

(5) A service case (of dimensions previously given) containing 100 pounds of the fine cordite was surrounded by wood and shavings which were set fire to.

The bonfire burned for 15 minutes, when the cordite in the case ignited and burned with a great rush of most brilliant flame for about 4 or 5 seconds. Some small pieces of the burnt wood were then thrown to a distance of about 12 yards. An end of the box was forced out. One side was partially forced out.

(6) Repetition of No. 5, but using fine instead of coarse cordite. After the bonfire had been burning for 7 minutes the cordite caught and went off with a dull muffled burst, which nearly amounted to a mild explosion. There was, however, certainly nothing approaching a violent explosion, as was shown by only one side of the box being displaced.

(7) Six service boxes, containing each 100 pounds of thick cordite, were placed together, five on end and one on the top; the centre box (in lower tier) was set fire to. It burned about six seconds and upset the side boxes, but did not throw off the top box; only the box which was ignited caught fire.

(8) Five service boxes, each containing 100 pounds of thick cordite (*i. e.*, those which remained from the last experiment), were placed in a pile, two, two, and one, breaking joint, and surrounded by wood and shavings, which were set fire to.

After 15 minutes, 1 box of cordite ignited.
After 15 minutes, 7 seconds, 1 box of cordite ignited.
After 15 minutes, 14 seconds, 1 box of cordite ignited.
After 15 minutes, 21 seconds, 1 box of cordite ignited.
After 15 minutes, 28 seconds, 1 box of cordite ignited.

Each box burned with a bright rush and burst of flame but without explosion.

The boxes were not broken up, and no fragments of the bonfire were projected beyond about 10 paces.

(9) A pile of eight services boxes, containing each about 75 pounds (total 600 pounds) of cordite, was surrounded with wood and shavings, which were set fire to.

The top box had a hole in it, which was roughly plugged, and this apparently caught fire and burned away non-explosively at 1 minute 10 seconds after the bonfire had been ignited.

The other boxes ignited in succession and burned away non-explosively.

The times were as follows:

	Min.	Sec.
First box	1	10
Second box	1	15
Third box	2	2
Fourth box	5	45
Fifth box	17	25

	Min.	Sec.
Sixth box	16	37
Seventh box	21	31
Eighth box	21	33

This powder has been tried in a 9.2-inch breech-loading rifle with reported good results.

Climatic tests in England are stated to have been very satisfactory, and similar tests are soon to be conducted in Canada and India.

Grakrut (Gray Powder).

A series of experiments with this powder have been carried out in Sweden for some time past with reported good results.

In competitive trials with ordinary powder in the new Swedish .315-calibre small arm, the following results were obtained:

Powder used.	Weight of charge.	Weight of bullet.	Muzzle velocity.	Chamber pressure (tons to square inch).
	Grains.	*Grains.*	*f. s.*	
Ordinary	72.5	231.5	1,755	12.5
Grakrut	48.6	231.5	1,965	14.7

In continuous trials the variations in muzzle velocities obtained did not differ from those obtained with ordinary powder.

In trials carried out by Swedish naval officers with a 37-millimetre rapid-fire gun, with this powder, results were obtained as follows, and are tabulated in comparison with those obtained with the same gun from its service charge of ordinary powder:

Powder used.	Weight of charge.	Muzzle velocity.	Chamber pressure (tons per square inch).
	Ounces.	*f. s.*	
Ordinary	9.6	1,808	11.2
Grakrut	6.0	2,259	12.9
Grakrut	7.0	2,509	15.9

LIBBRECHT POWDER.

This, an invention of M. Libbrecht, the director of the Wetteren Powder Factory, is supposed to have a gun-cotton base. In trials in Belgium from a 3.4-inch gun, charges of this powder gave greater velocities and less pressures than charges of ordinary powder of double the weight.

MAXIM POWDER.

This powder has been tried in Europe with reported excellent results.

It is obtained by treating high grade gun-cotton with a vaporized solvent.

Mr. Maxim specifies several methods of manufacture, but the following will give a general idea of the processes employed.

A quantity of high grade gun-cotton is reduced to pulp in a pulping machine and then washed thoroughly to remove any free acid that may have remained in it. It is afterwards dried and then moistened with acetone and subjected to the action of a mixture of six parts of ether to one of alcohol until it is partially dissolved. When sufficiently softened, it is either compressed into sheets under heavy pressure—from 20 to 40 tons to the square inch—or else forced through dies to form cords or strips.

In the method Mr. Maxim describes for making large-sized grains the pulp is placed in a receiver from which the air is afterwards exhausted. The vapor of the solvent is then turned into the receiver and allowed to act on the pulpy mass until it succeeds in partially dissolving it. This partially dissolved mass is then compressed in the receiver to the desired thickness, after which it is removed and cut into the shapes wished for.

If the powders produced as above prove too quick-burning, certain substances which have a tendency to reduce the rate of burning are mixed with the gun-cotton.

NOBEL POWDER, C/89.

Krupp and Gruson have made extensive experiments with this powder. Krupp's experiments have now extended over 2 years, and with reported very uniform results. Following are some of the interesting facts brought out.

It was found that the power of this powder as compared to brown prismatic is about the same in short guns, but increases materially up to a certain limit (not yet practically determined) with length of gun.

It was also found that, using the maximum charge capable of being fully consumed in each gun, the chamber pressures in guns of the same calibre, but of varying length of travel of projectile, differed in degree. In one instance, with two guns of the same diameter of bore, one of 28 calibres in length, the other of 40, this proportion was about 3½ to 3.

The following tabulated details of results from two high-power guns may prove of interest:

Gun used.	Powder used; size, .39-inch.	Powder charge.	Projectile.	Muzzle velocity.	Chamber pressure (tons per square inch).	Remarks.
		Pounds.	*Pounds.*	*f. s.*		
Krupp, 15 centimetres, 5.87-inch, 35-calibre, B. L. R.	Nobel, C/89.	16.5	112.4	1,720	9.2	The Danish service charge with this gun is 40.8 pounds prismatic powder, which gives a muzzle velocity of 1,789 f. s. to a 112.4-pound projectile.
Do................	Do.......	17.6	112.4	1,851	11.4	
Do................	Do.......	18.3	112.4	1,914	12.1	
Krupp, 21 centimetres, 8.24-inch, 35-calibre, B. L. R.	Do.......	46.3	238.1	2,132	11.9	The German service charge with this gun is 103.6 pounds of P. P. C/82, which gives a muzzle velocity of 1,738 f. s. to a 308.6-pound projectile.
Do..............	Do.......	48.5	238.1	2,185	12.4	
Do..............	Do.......	51.8	238.1	2,299	14.7	

SCHÜCKHER'S POWDER.

This, the invention of W. Schückher, an Austrian, is supposed to be composed of explosive starch and nitro-benzole, in varying proportions, according to the character of the powder required. The nitro-benzole is used as a solvent.

It is put up in grains, pebbles, cubes, cylinders, and disks, all of which have about the same appearance as ordinary powders and are very hard.

ARMOR-PROTECTION.

Cellulose.—According to a German paper, a very interesting test of this material has lately been made in Denmark. A 5-inch shot was fired through the cellulose belt of the Danish cruiser *Hekla*, entering the bow on the port side and, going clean through, coming out on the starboard side. The vessel then steamed for 3 hours at a speed of about 16 knots, and with the water rising high above the shot holes. The cellulose proved quite effective, as, at the end of the 3 hours, the water-tight compartment through which the shot had passed contained but 2 feet of water.

During French naval manœuvres this year the cruiser *Surcouf* ran down and sank a torpedo boat. A hole 12 inches long was produced in the bow of the cruiser, but the cellulose protection was sufficient to keep out all but a slight amount of water.

TORPEDOES.

The uncertainty as to the behavior of the Whitehead has been frequently exemplified during the past year.

A number have been lost from both ships and boats. The *Benbow* lost one in torpedo practice. During the visit of the German Emperor to England five Whitehead's went astray in torpedo exercises conducted for his benefit.

There is good reason to believe that the English have lost more than one hundred torpedoes in running since 1875. Of the number lost by other nations we can not speak from authentic information, but we know that mishaps in torpedo practice are not at all rare.

In the report of the part taken by torpedo boats during the English naval manœuvres of 1890, it is stated that "No. 57 fired at the *Invincible*, but her torpedo did not run." "No. 59 fired at the *Northumberland*, but missed her." "The *Anson*, which had not been claimed by the attack, had a curious experience. A torpedo struck her picket boat, glanced off the boat, then glanced off the ship, and ran to the breakwater."

On the night of April 12, 1891, the Chilian insurgent battle ship *Blanco Encalada* steamed into the harbor of Valparaiso unperceived, with the intention of making an attempt to destroy the Government armed tug *Mary Florence.* She succeeded in getting close to the tug and, apparently under the most favorable circumstances, discharged a Whitehead torpedo, which, missing the tug, passed on and struck a dry-dock in the harbor, which it completely destroyed.

About 4 a. m. of April 23, 1891, the morning being clear and the harbor light burning brightly, the Chilian torpedo cruisers *Almirante Lynch* and *Almirante Condell* steamed into the harbor of Caldera to attack the insurgent battle ship *Blanco Encalada.* The last-named was lying at anchor, helplessly exposed to every kind of attack. Her stay light was up and burning. No lookouts were stationed. No guns were in readiness for action. No picket boat had been sent out to guard against surprise, and her torpedo net defense was not rigged out. Such absolute negligence would be unpardonable even in times of profound peace.

The torpedo cruisers made for this easily distinguishable battle ship, and when at close range they fired four 14-inch Whitehead torpedoes in all from over-water discharge tubes. It was at first thought that two of these took effect a little forward of the beam, but later advices state that the underwater hull has since been examined by a diver, and a single hole found. This indicates that but one torpedo took effect.

The ship sank in a few minutes, and so complete was the surprise that over one hundred and fifty of the crew were carried down with her.

From newspaper reports we understand that a few days later the insurgent twin-screw, composite cruiser *Magellanes*, of 950 tons, was attacked by the torpedo cruisers *Almirante Lynch* and *Almirante Condell* and the first-class, 120-foot, 70-ton torpedo boat *Sargento Aldea.* This attack was not a surprise, and the *Magellanes* succeeded in driving her assailants off after a fierce fight. During this attack a torpedo was discharged from one of the torpedo vessels, which missed the *Magellanes* and, passing on, struck and sank a merchant vessel then at anchor in the harbor. This report has not yet been confirmed.

These results of Chilian torpedo operations give practical illustration to four important points: (1) The unreliability of this weapon as to accuracy in flight; (2) the effect of 66 pounds of wet gun cotton when exploded in contact with the double bottom of a vessel; (3) the great value of a fortunate hit; (4) the necessity for having a number of torpedoes in an attack, as, from uncertainty in flight, a single shot can not always be depended upon.

Only the new 18-inch torpedo is now being made at Fiume; these are to have a speed of from 32 to 33 knots for 437 yards, and 30 knots for 875 yards.

The new pattern English Whitehead is to carry a charge of 250 pounds of gun-cotton of 12 per cent. moisture, with a detonator of 16 ounces of dry gun-cotton, and a primer of from 35 to 40 grains of fulminate of mercury.

Many experiments have been carried on with this torpedo, one of which was to determine practically the degree of force necessary to project it from an over-water discharge tube in such a manner as to make it strike the water at the most favorable angle. A pencil was fitted to the head of the torpedo in such a manner as to cause its trajectory through the air, in its flight from its over-water tube to the water, to be marked on an outside vertical screen, thus determining the angles at which the torpedo struck the water under varying pressures of discharge.

Cases are known where the air chamber has either been intentionally exploded by machine-gun fire, or accidentally on striking sharp-pointed hard substances, with very destructive effects from the resulting fragments.

During the year ending December 31, 1890, 150 Whiteheads of the type described on page 135, No. IX, and 587 of the previously used type were constructed for the English navy.

The Buonaccorsi auto-mobile torpedo, the invention of an Italian of that name, has been experimented with in Austria with reported excellent results.

In this torpedo the motive power is compressed air confined in a chamber occupying more than than one-half of the volume of the torpedo. This chamber is connected by a hollow non-rotating shaft to two propellers fitted to revolve in opposite directions. No air engines, with necessary shafts and gearing, are employed, but the motive power is conducted through the hollow, non-rotating propeller shaft, and the principle of the Barker's reaction wheel utilized to revolve the propellers.

It is reported that the Vulcan Works of Stetten has purchased the patent rights of this torpedo for Germany and will soon inaugurate a series of practical trials.

Interesting and highly successful trials of the Sims-Edison controllable torpedo have been carried on in France this year. A run of 4,878 feet was made in 1 minute 46 seconds, and the torpedo was manœuvred with ease and certainty.

The Forges et Chantiers de la Mediterranée have undertaken the construction of the Sims-Edison torpedo in France, its electrical apparatus to be made by the Sims-Edison Company in the United States.

VICTORIA CONTROLLABLE TORPEDO.

This torpedo, the invention of Mr. G. R. Murphy, though not yet adopted by any government, has attracted so much attention abroad that a general description of its principal features may prove of interest.

The coast-defense type of this torpedo is similar in form to the auto-

PLATE X

VICTORIA TORPEDO

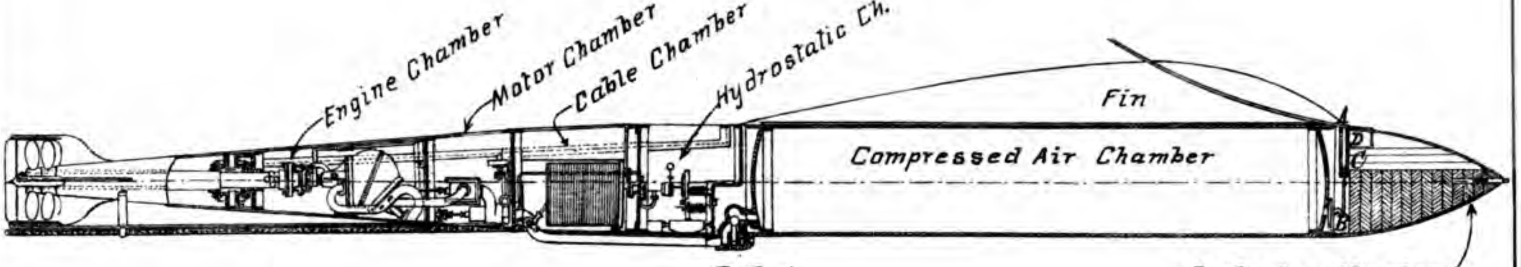


FIG. 1

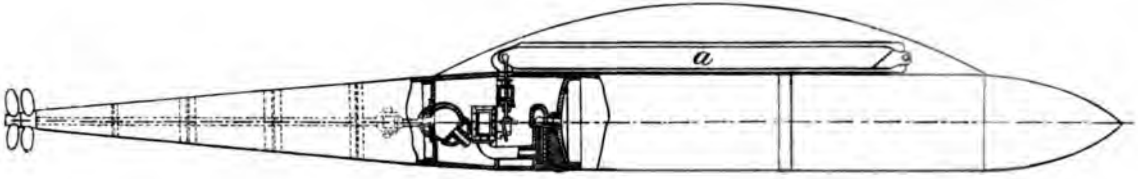


FIG. 2

mobile torpedoes now in general use, and is divided up into six compartments, as shown in Fig. 1, Plate XX.

The forward compartment contains the explosive charge, which is compactly stowed in the lower part, the upper part being divided into five compartments, four vacant and intended to contain water, the fifth, D, containing Holmes's light composition.

Attached to the forward bulkhead of the air chamber is a diaphragm B so connected to the piston rod of a piston valve C, moving vertically in the cylinder A, as to cause the piston to gradually descend in its cylinder as the air pressure decreases in the compressed-air chamber; allowing water to flow in through the thus opened top of the cylinder A to successively fill each of the four compartments mentioned above, in this manner adding weight forward to compensate for the loss of the expended air.

The compressed-air chamber is connected with the engine by means of an admission pipe as shown, this pipe being fitted with a valve operated by one of three motors in the motor chamber.

To the rear of the compressed-air chamber is that for the hydrostatic valve, which, with its pendulum and servo-motor, actuates a horizontal rudder to keep the torpedo at a set depth when running.

In rear of this is the electrical cable chamber. The torpedo is controlled from the firing station on shore through the medium of a flexible gutta-percha cable of a specific gravity not varying much from that of sea water, of which about 1,200 yards are coiled in this chamber, the remainder being coiled up at the firing station ready for unreeling. This cable contains three sets of separately insulated copper wires, by means of which the power necessary for controlling, steering, raising to the surface, and firing the torpedo is transmitted from suitable electrical batteries at the firing station to three magneto-electric motors placed in the next chamber to the rear. Of these motors the forward one is used to actuate the spindle of the compressed air valve and regulate the admission of compressed air to the spherical air engine in the after chamber. The second motor has two functions. With a direct current it acts along a rod connecting it to a fuze in the nose of the torpedo to fire the charge (unless caught in a net or boom protection the fuze is intended to act by percussion), but with a reverse current it will serve to actuate, by means of a rod and gearing, a horizontal rudder to bring the torpedo to the surface of the water. The rear motor serves to actuate the vertical steering rudders.

When the torpedo is first discharged the cable will be paid out from shore, that reeled up in the torpedo being held by a grip, which at any time, by means of a cord and spring, can be released by opening the air valve to its full limit, thus permitting cable to be paid out from the torpedo.

The fin is shown in the figure, and this torpedo can be used with or without a float.

The two propellers are right and left handed, similar to those of the Whitehead.

Mr. Murphy's intention is to so arrange that this torpedo can also be launched from fixed under water positions in harbor, a mile or more from shore. For this purpose the torpedo, with an accompanying buoy, is held by four locked arms in a cage moored at the bottom. The buoy contains a coil of electric cable, and the cage is connected with the firing station on shore by a cable containing five strands of copper wire, three of them for the operations described above; a fourth to cause the setting free of the torpedo and buoy; and the fifth, which is connected with electric cells, to cause the ringing of a bell at the firing station in case of accident to the torpedo or its cable. To operate the torpedo from such a position, it is released from its cage and then started off, pulling cable out of its buoy instead of from the shore as in the case given above.

Mr. Murphy has also designed the naval torpedo shown in Fig. 2, in which, instead of the hydrostatic valve used in the shore torpedo, he will use a dorsal fin in which will be secured a float, *a*, which, through a dash-pot and servo-motor, will operate a side fin to keep the torpedo about 2 feet under water.

Initial trials of this torpedo are expected to take place soon.

TORPEDO NETS.

A new torpedo net defense, the invention of Capt. A. K. Wilson, R. N., has been lately experimented with in England. Hollow steel booms of the usual length are to be arranged diagonally along the ship's sides at equal distances from each other. These are each to be slung by two chains, one to support the heel near the water line, the other to act as an after guy to the heel. The heel is not to be permanently secured to the side, but only to be retained in place, when its boom is rigged out, by an ordinary cleat. The topping lifts are to lead obliquely in the opposite direction to the set of the booms, so that when let go the booms and the steel torpedo net will rig out together until the booms assume their proper positions at right angles to the ship's sides. When the topping lifts are hauled upon, the booms and net should rig in together.

No experiments have yet been made in rough water to show whether the cleats are sufficient to keep the heels of the booms from unshipping or not.

The weight of naval opinion is still in favor of the Bullivant system, as carried out in many French vessels, in which the net is attached to steel booms fitted to be run in and out through the ship's side by means of suitable gearing.

TORPEDO DISCHARGING APPARATUS.

The Canet torpedo-discharging apparatus described on page 197, No. VIII, has since been modified in the direction of greater simplicity and general handiness, and is used in connection with a director similar to the one described on page 138, No. IX. This director is arranged to be fitted with the Canet illuminated night sight.

SUBMARINE MINES.

For several years past great activity has been shown in the development and improvement of submarine mines, to be used either offensively or defensively.

A type which has attracted much attention is one which can be used either as a stationary submarine mine or as a drifting torpedo. This, when planted, will automatically take and retain position at a depth below the surface for which previously set, and will afterward rise and fall with the tide. It can be set to become active at any desired length of time after planting, and by suitable means can be rendered inactive and caused to rise and float on the surface.

This type in an emergency can either be quickly planted as a harbor mine at any stage of the tide, or thrown overboard from a moving vessel to impede or destroy another in chase.

Ingenious methods have been invented for the automatic electric control of mines. In one of these the apparatus, which is intended to control any number of mines, joins on to the conducting wires of the mines, and is connected with the firing station by a single cable.

This apparatus will automatically indicate any injury to either the conducting wires, the mines, or the main cable. It will automatically isolate an injured mine from the circuit, and will automatically increase the strength of current at the moment of firing.

W. H. H. SOUTHERLAND,
Lieutenant, U. S. Navy.

IV.

ELECTRICITY ON SHIPBOARD.

By Lieut. HAMILTON HUTCHINS, U. S. Navy.

It is the purpose of this article to note the progress made during the past year both abroad and in our own country as regards the application of electricity to naval vessels, together with a brief discussion of some of the requirements and the best way of meeting them. The different ways in which electricity can be utilized to advantage on board ship are numerous and still increasing in number. There are many cases where other sources of power will still continue to be used, as being best suited to the conditions; but the extent to which electricity will be utilized will depend largely on the attention given by electrical manufacturers to developing and perfecting their electrical appliances, provided domestic material is to be used, since the Government has not as yet deemed it expedient to manufacture any of the apparatus that comprises the electrical equipment of its men-of-war. It may well be conceded, however, that the field of application is but partially developed, and the demand for its use as a source of power will likely increase for some time yet. Many minds are hard at work trying to improve the accumulator, and with success. It is reported that the English admiralty have recently decided to supply accumulators to ships and do away with all primary batteries.

Generally speaking, the past year has been marked by development in marine applications of electricity as follows: (1) A tendency to introduce accumulators and discard primary batteries; (2) an increasing demand for electric-motor power, principally for training and elevating heavy guns and for controlling the fire of machine guns; (3) improvement of dynamos as regards external field and its effect on the compass; (4) increased power of search lights and improvement of the apparatus for manipulating them; (5) improvement of governing power of high speed engines; (6) electric firing for rapid-fire guns; (7) systems for night signals; (8) increasing demand for the telephone and its tendency to replace other means of communication. In addition to these it must not be supposed that the lamps, motors, and other electrical appliances now used on board ship, or even dynamos, have reached a state of perfection, or that the requirements have been fully met. He will confer a great benefit upon mankind who will build a dynamo that has little or no external field, and at the same time light, compact, efficient, and strong. The marine compound dynamo should be self-regulating not only in preserving the potential constant, but also in preserving small variation of lead of the brushes with variable load. Other points can be cited if necessary to show that there is still room for improvement. No one questions the fact that we have some good electrical appliances on board the new ships, and we are indebted to a few of the leading domestic electrical firms for at once meeting the requirements in a fairly satisfactory manner with apparatus of American manufacture. But the conditions and requirements are continually subject to modification. We must keep pace with the times or else acknowledge that we do not possess the best, which we surely will not be content to do, for the unwritten policy of our Government is undoubtedly to have not only the best ships as regards construction but also as regards equipment. Our ships are considered the equal of any of their type as regards construction; our guns are equal if not superior to those abroad, and we will not be satisfied if we do not excel ships of other navies in the equipment.

The call for dynamos, motors, etc., for naval use is small compared to the commercial demand, and as our merchant marine comprises but few steamers of any size doing passenger traffic, it is but natural that our manufacturers should devote little attention to marine apparatus; and in order then that there may be no delay in supplying the electrical outfit of a ship, especially in time of war, we must offer the manufacturers sufficient inducement if we are to expect them to compete with foreign makers or even comply with the specifications. For instance, a contractor goes to the expense of designing a new type of dynamo, and if it fulfills the requirements he should be able to count on an order for a considerable number of them—in other words, sufficient inducement to enable him to keep a constant force, though small, employed on Government work.

On the other hand, a contract once made, the contractors should be required to comply strictly with the specifications, or else they must expect the apparatus to be rejected; or, at the most, accepted under a penalty. To be sure, the Government might manufacture its own apparatus, but with the present size of our Navy this would not be advisable, nor is it the custom elsewhere. We must then create a demand for marine plants to enable us to have a sufficient number of firms ready to supply them. This demand would be brought about of itself with a development of our merchant marine, and this is probably the easiest solution of the problem. The past year has shown notable improvement in the way of increased competition for supplying marine installations, and with the advent of a merchant marine on the high seas we could be ready for any emergency that might arise requiring the supply of a large amount of electrical material.

DISTRIBUTION OF LIGHT AND POWER.

The greater part of the electrical energy that is required on board ship at any one time is utilized for light and power in fighting and working the ship. The fighting efficiency must outweigh all other considerations. It will be granted, then, that the main problem is to supply electrical energy to the search lights, the incandescent lights used in time of action, motors for handling the guns and ammunition, and steering or other motors required when fighting or manœuvring the ship. And we do not solve this problem unless we at the same time give the system the protection from liability to injury which its importance demands.

The constant potential system of transmission, with a central station of supply below the protective deck, and the network of conductors amply protected, are necessary requirements.

The system consists of one or more compound dynamos, each of which can be used independently on any or all feeding circuits; or, two or all of the machines can be run in parallel, supplying simultaneously the search lights, motors, and incandescent lamps. The search lights, motors, and incandescent lights can be supplied simultaneously, either by feeding them all in parallel from a common "bus" bar; or, some of the dynamos can feed the search lights and others the incandescent lights, the two circuits being independent of each other. In time of action the former method is preferable, as will be shown later, and as it is easy to provide on the switch board for both arrangements, it will probably be done in future installations.

The motors used on board ship may be series, shunt, or compound wound, depending on the nature of the work they have to perform, and the "constant potential" system of transmission only requires that they shall all be wound for the same terminal E. M. F. The potential of the source of supply is 80 volts, and was adopted by the Navy Department 2 years ago. It is also 80 volts in the English navy; in the French navy, 70;* Italian navy, 65.

In view of the fact that the electric light has come to stay, at least for the present, and that electric motors are so well suited for handling the guns and ammunition, the importance of having the dynamos or batteries continue to supply light and power uninterruptedly during an action can hardly be overestimated. This means that not only must the different circuits be frequently interconnected, and the conductors low down in the ship and vertical when possible, but special attention must also be given to the location of the dynamo room and its arrangement. Then, in case all the generating sets are disabled for want of steam supply, we must throw on the storage battery, and thus continue, temporarily at least, to supply the most important lights and motors. It seems to be settled that all large fighting ships should have two dynamo rooms, the larger or war dynamo room being below the water line; and in case but one dynamo room only can be had, it should be below the protective deck if the ship is to be efficient in action. We will next consider the number and capacity of the generating sets that should be provided for any particular vessel. The idea is to provide all vessels, except torpedo boats and small vessels, like, for instance, the *Vesuvius*, with duplicate plants, and to provide for the varying needs of the service the Navy Department, some time ago, adopted the following standard sizes as regards output of the dynamos, viz: 25, 50, 75, 100, 150, 200, 300, and 400 ampères. The only sizes that have thus far been supplied to the service are of 25, 50, 100 and 200 ampères capacity, barring some of the belt-driven plants. Whenever space in the dynamo room will permit, the generating sets should be all of the same capacity for the sake of interchangeability. The engines and dynamos then, for any particular ship, should be alike in every respect, and on all important occasions the entire plant operated in parallel, one dynamo after another being shut down or made ready to be thrown in circuit according to the power required.

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* By a recent order, the voltage in the French Navy has been raised to 80.

It is not necessary for parallel working that the machines should all be of the same capacity, provided they are all wound for the same voltage. Should they differ in capacity, not only should the terminals and also the armatures be connected when they are thrown in parallel, but the resistances of their series coils must be in the inverse proportion to the currents they are to carry, in order that they may all have the same fall of potential through the series coils.

It may be asked, " What is the advantage in being able, if desired, to run everything in parallel?" Take one of the recent ships, for instance, the *Newark*. In this installation the switchboard provides for either of the three machines (which are all of the same capacity) supplying one-half or all the incandescent circuits or the search-light circuits, or one machine the incandescent circuits and the other two in parallel on the search-light circuits, or *vice versa*. Now, let us suppose, as would most likely be the case in action, No. 1 dynamo is feeding the necessary incandescent lamps (about one-half the total number installed) and the other two at full load are in parallel feeding four search lights (the latest and most approved search lights take 100 ampères each). Suppose it becomes necessary to shut down No. 2 dynamo on account of something going wrong to that set. In order, then, for the search lights to keep going No. 3 dynamo will be called upon to supply twice its normal full load, which it can not well do. What happens then? Its fuse blows, or its armature burns out, the search lights are disabled (at least temporarily, until the switch is closed, throwing the incandescent and search-light circuits in parallel), and confusion is the result at perhaps a critical moment. Or suppose that it had been No. 1 dynamo that went wrong; then the magazine light, for instance, would be extinguished until the multiple arching switch for arc and incandescent circuits was closed. This would also create confusion, unless the magazine candles were also lighted, as is the present custom. If, however, everything were run in parallel, one of the three sets could be suddenly shut off, the work would be equally divided between the other two, the lights would continue to burn uninterruptedly, and in an extreme case each machine would have to deliver 50 per cent. more than its normal full load, which, with our narrow heating limits, they could easily do for a long time and without undue sparking. With a plant comprising only two generating sets, provided both were already running at full load, there would be no great advantage in parallel connection of search-light and incandescent circuits unless both engine and dynamo were designed to stand the increased load; but in a plant with more than two sets, the advantage of being able to prevent the important lights from being extinguished even for an instant should out-weigh other considerations.* The writer is of the opinion that commercial practice both in this country and abroad has demonstrated that compound dynamos can be safely run in parallel, and each machine made to take its share of the load without difficulty. If such is not the case experiment should determine this point at once.

In fact, there are only two real objections that have thus far prevented the operation in parallel of arc and incandescent lamps. One objection that has been urged is in running a dynamo at 80 volts to supply arc lamps that require only 50 volts, thereby wasting an unnecessary amount of energy in dead resistance. But it must be remembered that the time element is a great factor in considering the expenditure of coal. The expenditure is due principally to supplying the incandescent lamps, as these are continuously in circuit during the whole 24 hours; whereas the search lights are used only for comparatively short intervals, and the loss due to an unnecessary amount of dead resistance will be a very small percentage of the total running expenses.

Another objection that has been made is that even with plenty of dead resistance in the search-light leads, it is always noticeable at the incandescent lamps (shown by the jumping) when the search lights are thrown on or off, which is most unsatisfactory to the incandescent-lamp consumer. The same thing would happen if a 5 H. P. motor were suddenly thrown in circuit. The reason for the above is that the current for the search lights is a considerable percentage of the total capacity of the machine, so that an appreciable time is required to vary the magnetism of the cores and reëstablish the potential at the terminals of the dynamo, whereas one extra incandescent lamp turned on or off would not be noticed. This is especially the case at the instant of striking the arc or before the motor begins to turn, for at such times the machine is called upon to deliver an abnormal current, and with the result of a temporary lowering of the potential.

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*In certain small vessels where there is no duplicate plant a full outfit of oil lamps is, of course, a necessity.

The above objection would have great weight in a shore installation, but it should have little or no weight on board ship; for, surely, when the search lights and motors are wanted everybody would be at their stations, or should be, and there would be no inconvenience resulting. Furthermore, contrast some of the now complicated switchboards with one where all circuits are fed through a common "bus" bar.

In determining what shall be the total capacity of the dynamos for any particular ship, we determine the maximum amount of energy for all purposes that is liable to be required at any instant, which, for instance, in the case of the armored cruiser *New York* will be from 900 to 1,000 ampères. Of course the idea is to have each generating set as large in capacity as possible on the grounds of economy and at the same time not so large but what there would always be a reasonable load on the machine that is in ordinary use for lighting purposes. A daily load diagram of the *Chicago* (in port) is shown (Fig. 1) where the load for the *greater part* of the 24 hours is about 80 ampères. The load for the *New York*, with approximately twice as many lights, would be 160 ampères.

If each unit, then, in the latter case is a 300-ampère dynamo, there would be always a fair load on the machine and it would be capable of supplying the greatest number of incandescent lamps that would be required at any time of the day without starting another machine. And as the total electrical energy that may be required at one time in this ship for light and power is about 80,000 watts, three of these units would be suitable. On account of the difficulty, however, that the manufacturers have had in even building satisfactory 200-ampère dynamos, the *New York* will probably have five sets of 200 ampères each. H. M.S. *Trafalgar*, with 96,000 watts to supply, has three 400-ampère dynamos. The curve of commercial efficiency of one of the *San Francisco's* generating sets is shown (Fig. 2), and it will be seen that it is not economical to run much below half load. Apropos of the fact that on board ship, with a 150 or 200 ampère dynamo, the normal load is about 80 or 90 ampères, the Desroziers dynamo, recently introduced in the French navy, possesses the extremely valuable feature of retaining a high efficiency on a light load, and other things being equal this machine is considered the most economical of any in use on board the ships of the French navy.

MARINE PLANTS.

The standard type of plant for use on board the new vessels of our navy continues to be an 80-volt compound-wound dynamo driven direct by, and on the same bed plate with a vertical two-cylinder double-act-

LOAD DIAGRAM, "CHICAGO."

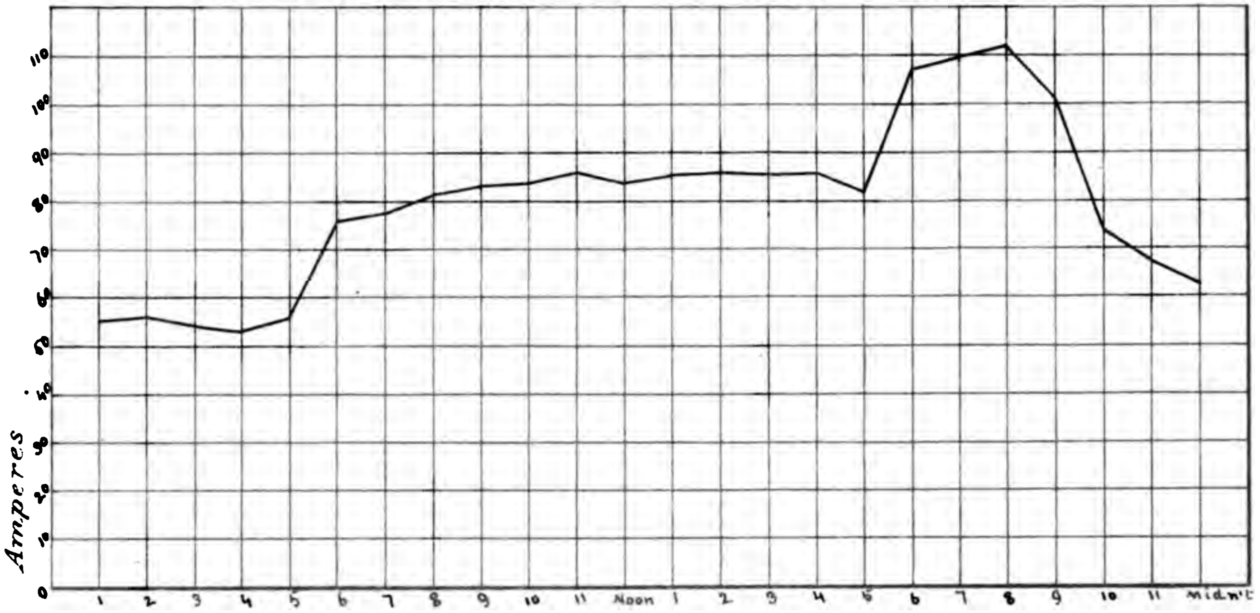


FIG. 1

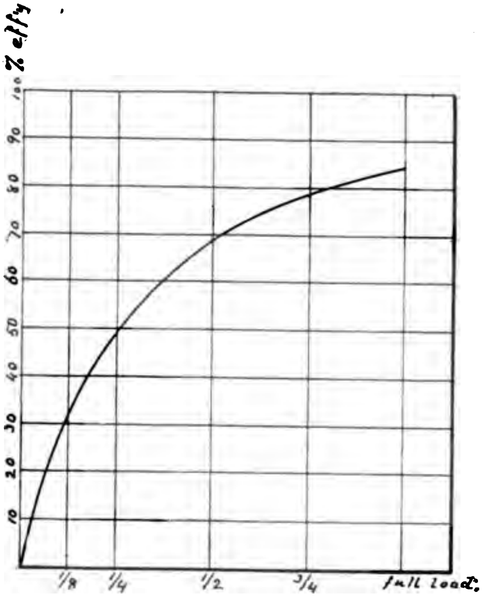


Fig. 2.

ing engine. The speed is in most cases about 400 revolutions; in some of the smaller types, 500. As all the most recent ships building have auxiliary boilers and condensers, the chance for still further improving the economy lies in the engines and dynamos themselves. No one special design of magnetic circuit in the dynamos has been required thus far in the specifications, though the standard plants at present in use are all multipolar.

The following table shows the vessels that are already supplied with modern naval standard plants, that is, generating sets composed of 80-volt compound-wound dynamos driven direct by double-acting two-cylinder engines on the same bed plate:

Ship.	Speed in revolutions.	Type of generating set.
Dolphin	800	A. and S. simple, vertical; T. H. multipolar.
Charleston	400	U. I. W. compound, vertical, inclined; Edison multipolar.
Yorktown	400	A. and S. simple, horizontal; Edison multipolar.
Petrel	500	A. and S. simple, vertical; T. H. multipolar.
Newark	400	Do.
Pensacola	400	A. and S. simple, horizontal; Edison multipolar.
Baltimore	400	Do.
Vesuvius	500	A. and S. simple, vertical; T. H. multipolar.
Miantonomoh	400	Do.
Philadelphia	400	A. and S. simple, horizontal; Edison multipolar.
San Francisco	400	U. I. W. compound, vertical, inclined; Edison multipolar.

Although simple engines have been the rule heretofore, it will be noticed that compound engines are supplied to the *Charleston* and *San Francisco.*

The principal requirements of a marine plant are compactness, lightness, small external field of dynamo, interchangeability, economy, and efficiency at all loads. Naturally the order of their importance will vary somewhat with the type and size of the ship in which they are to be installed. The problem is to obtain these requirements without sacrificing too much their strength, simplicity, and endurance. The *Dolphin*, for instance, has recently been refitted with a plant in which the speed is 800 revolutions per minute. The endurance of this double-acting engine will be watched with interest, as raising the speed means a gain in weight. Where the plants of vessels are of sufficient size to render a saving of coal possible, the compound engines will probably be preferred to the simple, as if vertical they occupy but little more space and the increase of weight is slight.

The following tables afford a comparison of recent direct driven plants, as regards compactness and lightness.

DIRECT DRIVEN SETS OF OVER 20 KILOWATTS OUTPUT.

[Floor space=extreme length over all×extreme width over all.]

Ship.	Combination.	Watts output.	Speed.	Weight.	Floor space sq. feet.	Watts output per square foot of floor space.	Watts output per pound of weight.
French cruiser *Tonnerre.*	4 pole; 300 ampères. Vertical, single cylinder.	21,000	350	7,040	22.4	937	*3.0
Ship lighting plant, King, Brown & Co., England.	Multipolar; 400 ampères. Vertical, compound.	44,000	300	8,900	25.5	11,725	4.9
....	Parsons turbo-electric generator; 400 ampères.	32,000	....	3,531	21.0	1,481	‡9.0
English Navy..........	Siemens "*Navy;*" 2 pole, 400 ampères. Belliss open, vertical, simple, 2-cylinder, double-acting engine.	32,000	320	11,480	28.05	1,140	2.8
English Navy..........	Siemens "*Navy;*" 2 pole, 300 ampères. Belliss open, vertical simple, 2-cylinder, double-acting engine.	24,000	320	9,408	23.25	1,032	2.5

* Designed also for 80 volts, same current.
†Most compact large plant.
‡ Lightest large plant.

DIRECT DRIVEN SETS 10 TO 20 KILOWATTS OUTPUT.

Baltimore...............	Edison multipolar—200 ampères. A. and S. double, horizontal, double acting.	16,000	400	6,743	47.5	347	2.4
Charleston, San Francisco, Monterey.	Edison multipolar—200 ampères. Inclined, vertical, compound.	16,000	400	6,880	25.5	626	2.3
Newark.................	T. H. multipolar—200 ampères. A. and S. vertical, double, double acting..	16,000	400	6,310	26.7	600	2.5
Ship lighting plant, King, Brown, & Co., England.	2 pole, 120 ampères. Single cylinder, vertical.	12,600	285	4,816	14.9	845	2.6
....	Parsons' turbo-electric generator—200 ampères.	16,000	......	2,688	13.9	*1,151	†5.9
French cruiser *Troude.*	Multipolar (6 pole), 150 ampères. Vertical, compound.	10,500	350	5,940	22.4	‡470	‡1.7
French cruiser, *Davout.*	2 pole—200 ampères. 2-cylinder tandem.	14,000	350	6,380	42.1	‡332	‡2.2
Italian Navy...........	4 pole—300 ampères, Victoria. Vertical, 2-cylinder.	19,500	250	10,143	31.6	617	1.9
Do................	4 pole—200 ampères Victoria. Vertical, 2-cylinder.	13,000	300	7,871	25.1	518	1.7
English Navy..........	Siemens "*Navy,*" 2 pole, 200 ampères. Belliss open, vertical, simple, 2-cylinder, double acting.	16,000	320	7,168	18.85	848	2.2

* Most compact medium-sized plant.
† Lightest medium-sized plant.
‡ Designed also for 80 volts, same current.

DIRECT DRIVEN SETS UNDER 10 KILOWATTS OUTPUT.

Dolphin..............	T. H. multipolar—100 ampères. A. and S. vertical double, double acting.	8,000	800	3,000	16½	491	2.6
French torpedo catchers.	Sautter-Lemonnier dynamoteur, type D, 90 ampères.	6,300	400	2,860	9.4	670	2.2
Vesuvius..............	T. H. multipolar—50 ampères. Vertical double, double-acting.	4,000	500	3,080	18.3	213	1.3
....	T. H. multipolar—25 ampéres, Brotherhood engine.	2,000	850	933	8.4	238	2.14
Dutch Torpedo boat, "*Cerberus.*"	2-pole—70 ampères. Single cylinder, vertical.	4,550	450	840	5.6	812	*5.4
Torpedo station.......	Parsons' turbo-electric generator, 30 ampères.	2,100	9,000	400	5.5	380	5.2
French torpedo boat *Agile*.	Desrozier's dynamo, 50 ampères. Single cylinder, vertical.	3,500	......	1,540	9.1	384	2.3
....	Victoria dynamo—60 ampéres, Brotherhood engine.	3,900	750	800	4.7	†830	4.9
....	T. H., 2-pole, 25 ampères, Brotherhood engine.	2,000	850	886	8.4	238	2.25
French, 2nd-class, torpedo boats.	Sautter-Lemonnier dynamoteur, type C, 45 ampères.	3,150	500	1,540	7.6	414	2.0
French steam launches.	Sautter-Lemonnier dynamoteur, type B, 25 ampères.	1,750	500	990	6.6	265	1.8

* Lightest small plant.
† Most compact small plant.

The English direct driven sets are of two kinds: First, the very slow speed sets driven up to 200 revolutions per minute by the ordinary open type of double-acting engine; second, those driven by a closed type of single-acting engine which go to 400 or even 500 revolutions per minute. Mr. R. E. Crompton, in an interesting lecture on electrical engineering, says as follows:

> I have put down a great number of large-sized engines made by Willans & Robinson, of the closed type, and both in economy of steam and oil, labor, freedom from vibration and noiselessness, these engines are most remarkable specimens of modern engineering. Before I leave the subject of direct-driving engines I must point out the extreme importance of the proper proportioning of the areas of pistons of compound engines used for this work. If the right proportion between the cylinders is not hit upon, there is a great tendency to unequal turning throughout the strokes, which makes a most unpleasant effect on the lights, every revolution of the engine being perceptible in the rise and fall in brilliancy of the lamps, and it is quite impossible to get over this fault by increasing the weight of the fly-wheels. With triple expansion engines, with cylinders side by side, the difficulty does not appear so great; at least, some of the most regular-turning engines of this speed that I have ever seen were triple-expansion engines. An improvement in the direction of simplification that was introduced, partly by my own firm and partly by Messrs. Willans, was the omission of the dynamo bearing, the armature of the dynamo having a coupling forged or driven on to it, and bolted metal to metal to a coupling at the end of the crank shaft. This intermediate bearing was always a great trouble and cause of heating, and since we have done away with it we have greatly reduced the cause of stoppages of direct-driven sets.

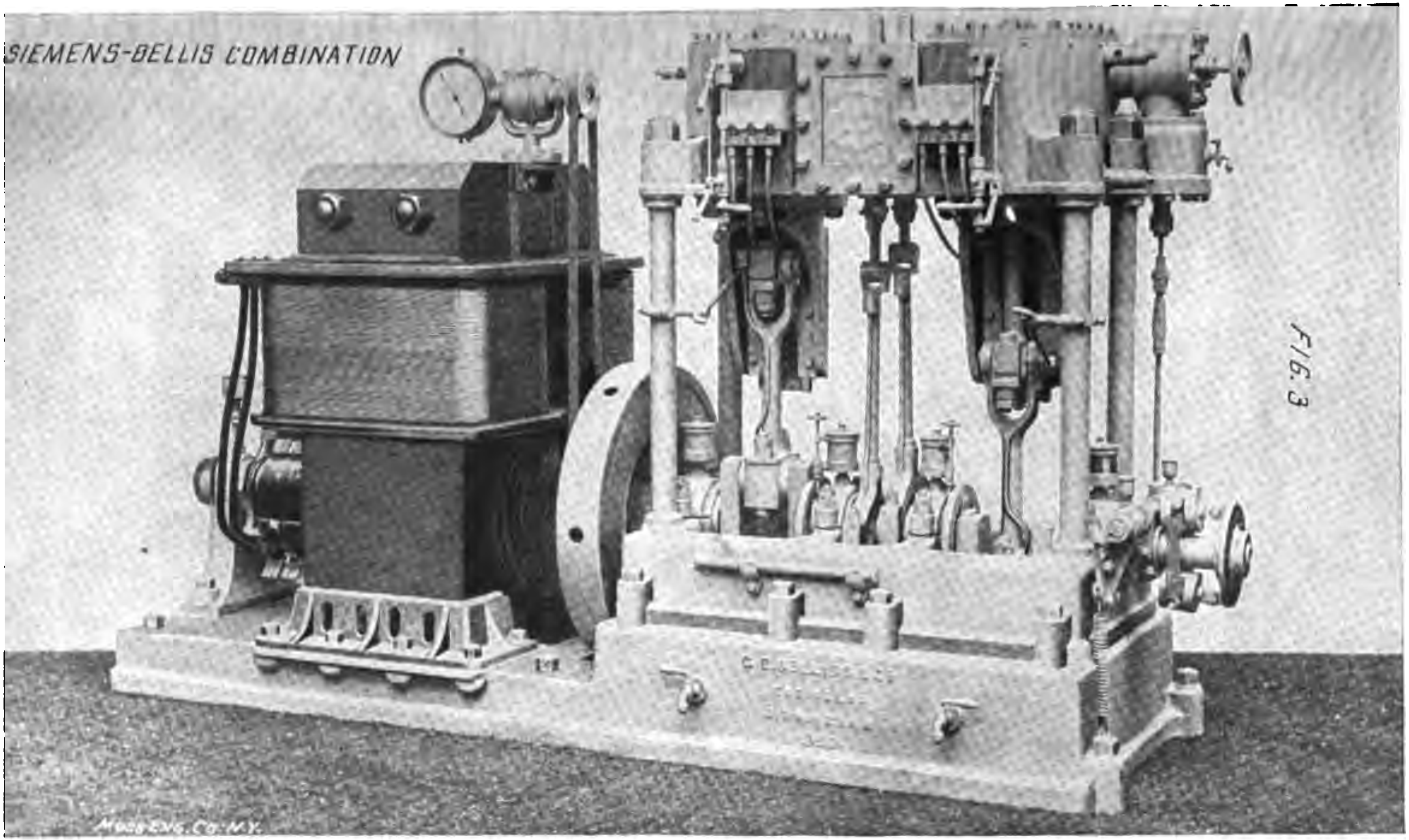
The combination of plant described on page 184 of General Information Series, No. VII, consisting of Raworth engine and "Victoria" dynamo with friction coupling, is still used in the English navy in some small vessels, but with the larger-sized plants the direct-driven sets are found more reliable and satisfactory, and require less attention than the geared sets.

The type of direct-driven plant that is most extensively used in the English merchant service is what is known as the "Tyne" combination, consisting of vertical engine and four pole dynamo (two brushes). A novel type of direct-driven combination has recently made its appearance in England. It consists of open compound tandem engines directly connected to dynamo and running at 380 revolutions. Two of these sets, of capacity 80 volts and 400 ampères, have been supplied to H. M. S. *Rupert*, refitting. Three similar sets have been placed in the Portsmouth dockyard. For the merchant marine, nearly all vessels are at present fitted with single cylinder, direct acting engines and dynamo, the object being to secure a good, practical machine which will run constantly without repair or breakdown. For naval purposes economy and efficiency are considered more important.

The British Admiralty now prefer the double-acting type, as the result of their large experience with both single and double acting types of vertical compound engines. A plant which develops 32,000 watts (80 volts, 400 ampères) is run at 320 revolutions per minute as their solution of the critical speed, but it remains to be seen whether the increased wear and tear on the engine, due to the increase of speed from 200 to 320 revolutions is justified by the saving in size of dynamo and the reduced weight of the combination. In this connection it may be questionable whether the excellent qualities of our own double-acting engines, which run at an even higher speed, 400 revolutions (for 16,000 watt dynamos), are not gained at the expense of great wear and tear.

Fig. 3 shows the present "Navy" type of engine and dynamo as adopted by the English Admiralty. The illustration shows one of a set of nine which Messrs. G. E. Belliss & Co. of Birmingham, have recently completed for the new battle ships. The dynamo is manufactured by Siemens Brothers. The firm of Belliss & Co. have already supplied during the last year or two (since the open compound type of engine has been adopted) about twenty of these sets of dynamo machinery for various ships, including H. M. S. *Nile*, *Sanspereil*, *Phœbe*, *Alexandria*, *Defiance*, *Royal Oak*, *Resolution*, and *Revenge*, and the official trials at Portsmouth have given complete satisfaction.

The engine is well balanced, the cranks being opposite and the valves arranged to give the amount of compression required for economy and quick running. The makers have aimed at making an engine capable of running for long periods without requiring adjustment, and with such simplicity of parts as shall render the liability to damage as small as possible, and give the utmost facility for adjustment or repair. The



SIEMENS-BELLIS COMBINATION

FIG. 3

Moss Eng. Co. N.Y.

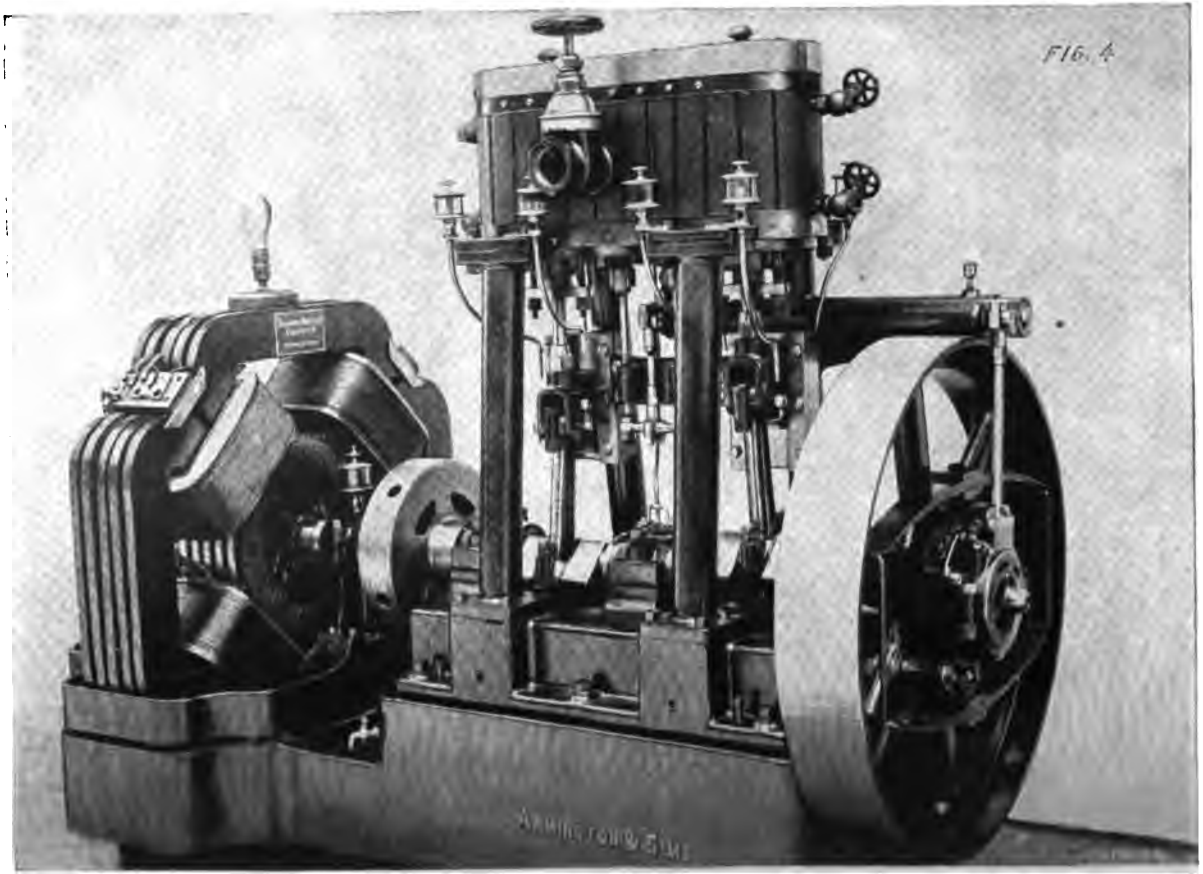


FIG. 4

cylinders are supported on four stout steel columns fitted into long sockets accurately bored to correspond in cylinder and bed plate. The guides are carried in the cylinder casting and are designed to be very readily adjusted. The piston valves are placed at the back of the engine and driven by a single lever arrangement from the H. P. connecting rod. The governor is placed at the end of the crank shaft, and is capable of controlling the engine to within 3 per cent. of the maximum revolutions when the full load is suddenly thrown off. The engine and dynamo are carried upon a combination base plate, and each set is subjected to thorough working tests at Messrs. Belliss & Co.'s works, where a very complete installation of electrical resistances and recording instruments have been fitted for the purpose. In addition to these each set supplied for service in the navy is subjected to official tests at Portsmouth dockyards for 6 hours' continuous running at full load with a guaranteed minimum consumption of water per E. H. P. per hour, and the effectiveness of the governor and general perfectness of the whole construction and suitability for the service are determined.

The 200, 300, or 400 ampère sets all run at 320 revolutions. Still more recent vessels are the *Royal Sovereign* and other battle ships. Each of these battle ships is to have three generating sets of 80 volts, 400 ampères each. The combination consists of a "Navy" Siemens dynamo (see Fig. 3) driven direct at 320 revolutions by a Brotherhood vertical compound double-acting engine on the same bed plate.

Parson's Turbo-Electric generator and the "Westminster" dynamo are also quite extensively used in the English Navy.

We have in our own service at present two types of the marine dynamo on board vessels in commission, one an Edison multipolar machine and the other a Thompson-Houston, multipolar also. The former has been described in a previous publication; a description of the latter may be of interest to the service.

As installed on board the *Petrel* the plant consists of two generating sets, each composed of a dynamo of 80 volts and 50 ampères, at 500 revolutions per minute, directly connected to an Armington & Sims vertical, simple, two-cylinder double-acting engine, each cylinder 5 by 3 inches. Each dynamo and its engine is mounted on a combination bed plate. The dynamos are compound wound and self-regulating for constant potential, the only hand regulation required being the adjustment of the brushes for varying load. The machines are mounted on cast-iron beds secured to the combination engine and dynamo bed plates by eight tap bolts through flange of bed and inner flange of bed plate. The beds are insulated from the bed plates by hard rubber washers, the bolts being insulated by rubber washers and boushings. The dynamos have four poles arranged around the periphery of the armature as shown in the view of one of the *Newark's* generating sets (Fig. 4). The magnets are of five parallel plates, arranged as shown; they are of wrought-iron and spaced one-half inch apart. In the magnet cores the intervening spaces are filled in with cast-iron, forming a solid core, the whole being bolted securely together. The four magnets are secured through lower one to the bed, one bolt through each plate. The spools carrying the windings are of sheet-iron, and slip tightly over the cores; they are faced with brass flanges, and the windings are insulated from the body of spools by paper. The wrought-iron cores with cast-iron filling pieces extend through the spools and are carried to within one-sixteenth of an inch and encircling the armature. Owing to the peculiar relative position of the different magnetic fields, the external magnetic effect of the dynamo is said to be inappreciable. In fact this machine is so neat in design and successful in operation that it is worth while going into details in describing it, fulfilling as it does so many of the conditions to be met on board ship, such as compactness, lightness, small external field, freedom from mechanical injury, ease in running, and but little attention required in operation. No one can fail to observe that the design is good magnetically, the magnetic circuit being almost entirely of wrought-iron and containing no joints, which are so conducive to high magnetic resistance. The armature is of the Gramme ring type. The core is built on a spider frame with five radials, secured to the shaft by collars at each end. It is built up of alternate sheets of sheet-iron and card-board, the whole being bolted through and through. In the dynamos supplied to the *Petrel* there are four points of commutation 90 degrees apart, while in those supplied to the *Newark* one pair of brushes only are necessary 90 degrees apart, the coils of the same potential being cross connected. The latter method is preferable for machines of the size of the *Newark's*, on account of convenience and less friction, provided the insulation and ventilation of the armature coils is satisfactory.* The connections of the machine are shown in Fig. 5, the field winding being of the short shunt type. As regards the connecting of the shunt field for compound dynamos, there are in use both what are known as the "long shunt" and "short shunt" type. In the former type the current in the series field is the same as that in the armature, whereas in the latter type it is the same as that in the external circuit. With either type, when a second machine is thrown in parallel, not only the terminals but the brushes must also be connected together, so that in case one machine falls a little behind, its series field will not be reversed.

The following data on the dynamos of the *Petrel* may be useful for purposes of comparison:

Number of commutator divisions	88
Number of layers on armature	2
Number of turns per commutator segment	7
Size of armature wire	.102

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* With dynamos of, say, 10 H. P., or less capacity, it is better to use bipolar machines and avoid altogether the use of multiple brushes and cross connections of armature coils.

CONNECTIONS OF MARINE DYNAMO, "PETREL."

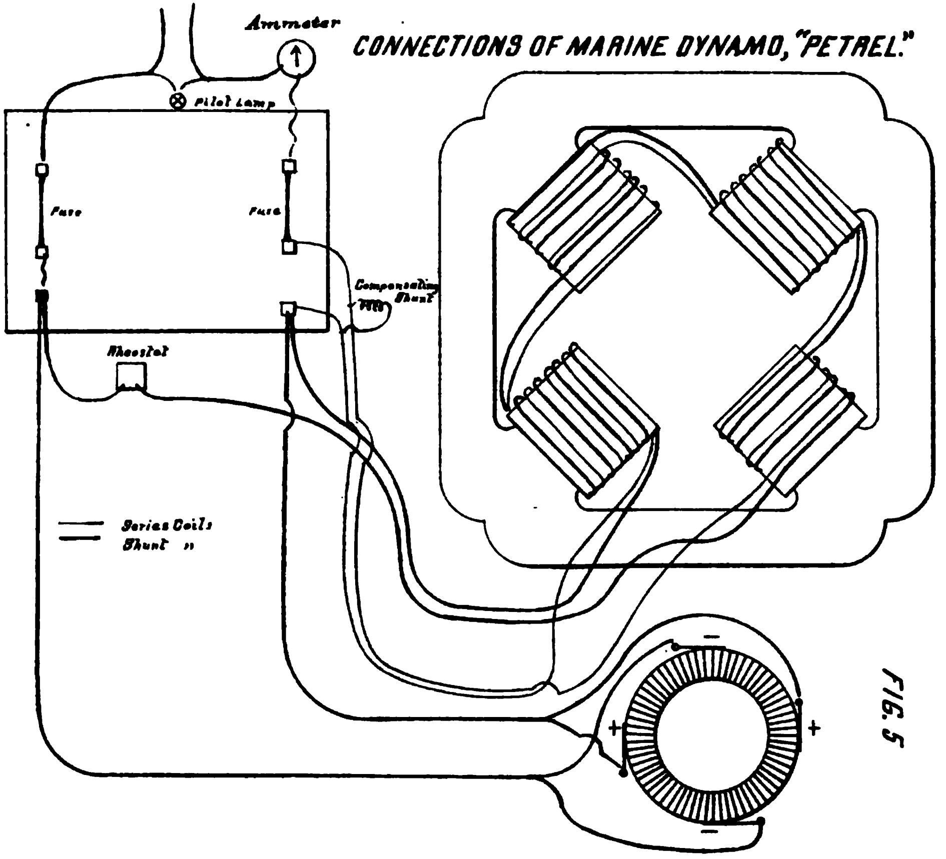


FIG. 5

Size of wire of series coils, 2 in multiple		.162
Size of wire of shunt coils		.081
Resistance of armatures, cold		.057
Resistance of armatures, hot		.06
Resistance of series coils, 4 in series, cold		.028
Resistance of series coils, 4 in series, hot		.03
Resistance of shunt coils, cold		14.
Resistance of shunt coils, hot		14.4
Number of series turns on each spool		12¼
Number of shunt turns on each spool		635
Series ampère turns, full load		2,500
Shunt ampère turns, full load		12,700
Diameter armature	inch.	14.875
Total length of wire on armature	feet.	950
Total weight of wire on armature	pounds.	34
Total weight of wire on shunt	do...	162
Periphery speed		2,387
Volts per yard of armature conductor, one-fourth length of armature wire.		.99
Weight of dynamo		1,331
Total weight of copper		216
Watts in exterior circuit per pound of weight		3
Watts in exterior circuit per pound of copper		18
Watts in exterior circuit per pound of armature copper		118
Current density in armature per square inch		3,125
Energy in armature, full load	Watts.	185
Energy in shunt field	do..	435
Energy in series field	do..	75
Electrical efficiency, full load	per cent.	90
E. M. F. in armature		84.9

In view of the present extensive use of multi-polar machines in our service, a few notes in regard to their advantages and construction may not be amiss. The speed of the dynamo with the direct connection being limited to that of the engine, it becomes necessary to design the dynamo so that although run at low speed it will still have all the essential features of machines run at the higher speeds. The two factors of the output are the voltage at the terminals and the current. In the design of any dynamo the only limit to the current that it will give is the size of the wire on the armature. The value of the E. M. F. depends on the number of lines of force cut in a given time; in other words, we can with the same amount of copper and iron in the machine and the same number of turns on the armature develop the same E. M. F. at a lower peripheral speed by the adoption of the multipolar type. The multipolar type admits of more lines of force in the magnetic circuit; thus the number of revolutions can be reduced without necessarily increasing the size of the armature. Thus the low speed compels us to adopt a field of several poles, as four or six, and with a less weight than the single magnetic circuit type. This type of slow speed dynamo finds its field not only on board ship, but also in the commercial demand for slow speed motors, in order to dispense with countershafting, etc. As before stated, there are two methods of coupling up the armature circuits of these dynamos. One is to have as many brushes as poles, and the other is by a system of cross connections in the armature or commutator, which connect those coils that are simultaneously undergoing the same induction. In the latter method a single pair of brushes suffices, and these bear on the commutator at two neutral points, exactly as in a two-pole machine.

It will be noted that in a multipolar machine there are as many neutral points as there are poles, and that any two can be selected for the brush contact as is most convenient, one positive, the other negative. For instance, in a 4-pole machine there are two points of highest potential and two points of lowest; in a 6-pole there are three neutral points of each sign, and so on. It is customary of course to select the two that will be most convenient for adjusting the brushes. For instance, in Fig. 6, where N represents the external and S the internal poles of the Edison marine dynamo, there are four neutral points, *a*, *b*, *c*, and *d*, of one sign, and four, *a*′, *b*′, *c*′, and *d*′, of the other sign. Two brushes 135 degrees apart, as at *d*′, and *b*, are used, though it is obvious they could be 45 or 225 degrees apart instead, as at *a* and *a*′, or *a* and *c*′. In the T. H. multipolar type the neutral points (Fig. 7) of opposite signs must be

Fig. 6.

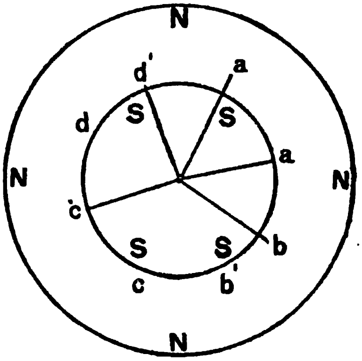


Fig. 7.

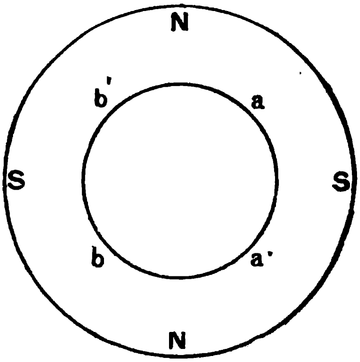
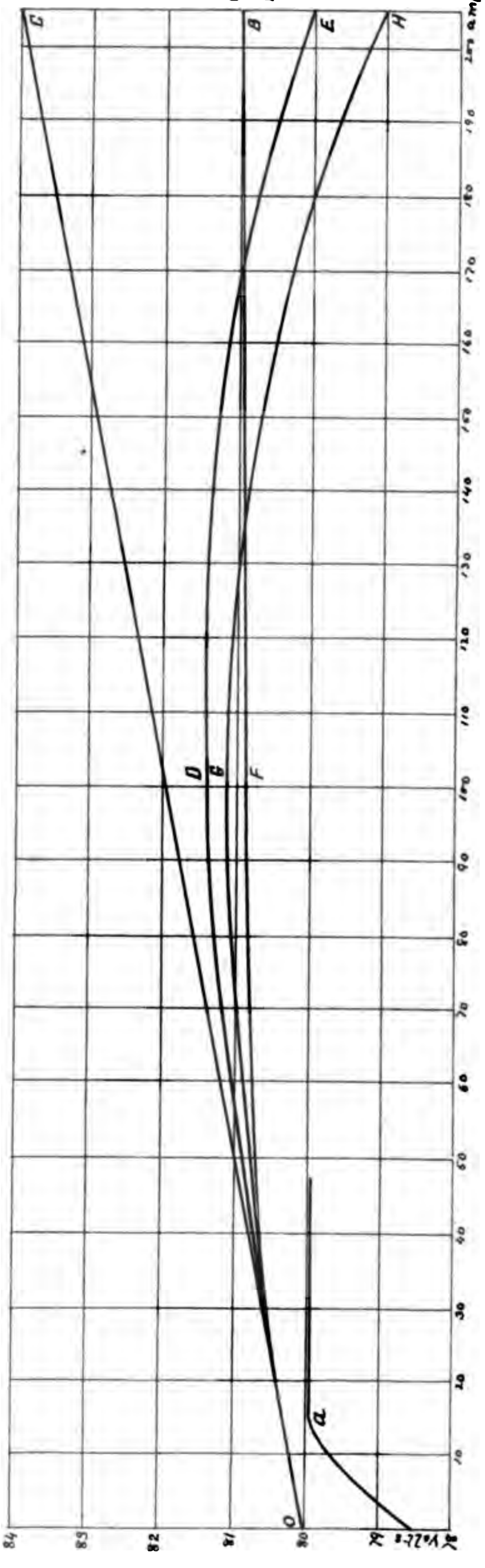


FIG. 8



C
B
E
H
D
G
F
O
a
84
83
82
81
80
79
78 Volts
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200 amp.

90 or 270 degrees apart, in accordance with the design of the magnetic circuits.

Nor is it necessary with an armature of a given number of coils to confine ourselves to the arrangement of having all the coils that are undergoing the same induction connected in parallel. For instance, take a 4-pole machine with 96 coils on the armature; we can have four parallels, 24 coils in each, or if we desire twice the voltage and less current, we can connect two opposite coils in series and have two parallels of 48 coils each. A modification of the multipolar ring winding is shown in the Electrician for December 13, 1889, where each coil is connected to *n* segments at intervals of $\frac{360}{n}$ degrees, where *n* is the number of pairs of poles in the field. This winding enables the number of commutator bars to be increased without a corresponding increase in the number of coils. The connections are complicated and troublesome, as can be imagined from an inspection of Fig. 21 in the above volume of the Electrician. This winding adapted to a disk, is said to give extraordinary results in the Desrozier machine.

A few words in regard to the characteristic of the marine dynamo. Could we build a dynamo with no armature resistance, the shunt dynamo would answer our purpose for preserving constant potential for all variations between no load and full load, and we would not require any series turns; but the conditions necessitate a small amount of armature resistance, and besides, when there is any load on there is an additional fall of potential due to the demagnetizing effect of the armature winding; hence the compound winding is a necessity. Now the next point to consider is whether it is better to preserve the potential constant at the terminals or at the centre of distribution. If the resistance of the leads between the dynamo terminals and the distributing centre is constant, as is frequently the case on shore, it is evidently better to over-compound the machine, especially in installations where there is a drop of several per cent. at full load; in this case the series ampère turns will cause the characteristic to gradually rise between no load and full load as in OC (Fig. 8). But on board ship it is necessary to a certain extent to control the lights on the different circuits from the dynamo room; there will be times, for instance, when all the circuits will be in use; at other times only a few circuits; moreover, the distances are short and the factor of safety large as regards the amount of copper used; thus the drop is rarely more than 1 per cent. to feeding centres, so that almost absolutely constant potential is required at the terminals with all loads. The iron of the machine must be so designed that the characteristic is as nearly straight as possible over the whole range between open circuit and full load and the curve should not turn downwards at the end; consequently there should be plenty of iron in the magnetic circuit, particularly in the armature.

Owing to the fact that the magnetizing force (ampère turns) changes along a *line*, while the magnetic resistance changes along a *curve*, it is impossible to obtain for the dynamo alone a characteristic that is a perfectly straight line even with absolutely constant speed. We can either allow a slight fall of potential on open circuit and have a characteristic like OFB, or we can require the same potential at no load and full load; in the latter case the potential will necessarily be slightly high for intervening loads, and with constant speed we will have a characteristic like ODE. Even with a variable resistance in the feeders we can keep our original number of series turns and still preserve the potential constant at the distributing centre with varying load, by adding a resistance in shunt with the series winding, and thus vary the series ampère turns instead of overcompounding on the machine itself; but of course this necessitates hand regulation, and is objectionable with the conditions on board ship.

The effect of changing the load, on account of the demagnetizing effect of the armature, is to cause the machine to overcompound with decreased lead and to undercompound with increased lead. In some commercial types of machines, notably the Thompson-Houston, the series coils are wound obliquely over the armature, the idea being to counteract the demagnetizing effect of the armature current in addition to increasing the armature induction enough to allow for the armature resistance at full load. Mr. Swinburne shows that this arrangement in a large machine is of little advantage, and he predicts hereafter the use of some form of reversing pole-piece, so that the machine can be regulated by moving the brushes backwards or forwards without producing sparking. Such an arrangement would do away with much of the series winding on the fields, and the advantages to be gained by such an arrangement would altogether be very great. The brushes would not need to be shifted with varying load, thus saving attendance and wear. These remarks are especially applicable to the marine dynamo, which at times is subjected to sudden variations of load.

In a recent interesting article by Dr. Louis Bell, the distortion of the field is said to be much less in the Siemens armature than in the Gramme type.

To add to the self-regulation of the marine dynamo a slight increase of ampère turns in the series coils should be allowed in the design in order to compensate for the slight falling off in engine speed as the load increases. In other words, the dynamo should be overcompounded enough to make the characteristic of the combined engine and dynamo similar to OFB (Fig. 8). This once attained we would have for the characteristic of the dynamo alone, a curve somewhere between OFB and OC, the engine being run at absolutely constant speed obtained by throttling. In other words, the natural variation of the engine when controlled by the governor and beginning with a speed sufficient to generate 80 volts at no load, would as the load increases tend to neutralize this small amount of overcompounding, and we would have a practical characteristic for the generating set similar to OFB or ODE.

It is better to take OFB as the ideal external characteristic to attain rather than ODE, for otherwise the falling off in speed with increasing load would most likely produce a curve similar to OGH; and besides, on board ship when the load is light, which is generally late at night, we can easily afford to allow the lamps to burn slightly below normal; in fact this has been the common practice with our vessels for some time for the sake of economy.

The characteristic of one of the *Petrel's* generating sets shown in curve "a," is evidence of what can be done towards attaining the ideal characteristic with a 50-ampère dynamo and an Armington & Sims two-cylinder double-acting engine, the readings being—

Revolutions.	Volts.	Ampères.
501	79.1	9.5
500	80	14
500	80	20
498	80	30.5
496	80	34.5
496	80	39
495	80	47.75

As regards efficiency, our latest specifications require at least 80 per cent. for the commercial efficiency of the generating set (85 per cent. in some of the large plants), that is, the ratio of the indicated horsepower of the engine to the output of electrical energy measured at the dynamo terminals. This requirement is in many cases exceeded in some of our plants and they will compare favorably with foreign plants. A point of great importance in the design is that the efficiency should be high not only for full load, but also at comparatively small loads. It is hardly possible to obtain accurate data, except for the most simple tests, with the means at hand and under conditions found in the ship's dynamo room. The plant should be thoroughly tested at some shore station or other locality where the proper facilities are at hand for a thorough examination of the dynamos and engines, both as regards their construction and working, leaving only the insulation and duration tests to be made on board ship previous to the acceptance of the installation. The heating test should also be made on shore, unless the vessel is provided with proper facilities for measuring accurately the resistances, both hot and cold, and thus determining the rise in temperature.

Bearing in mind that the electric-light engine has generally to work harder and longer than any other in the ship, the light being required both when in port and at sea, the matter of economy is of some importance. The economy of engines and dynamos has been improved, both by increasing the efficiency of the dynamos and by reducing the quantity of water required by the engine itself. Naturally, with a high steam pressure, and compound engines, combined with the use of a condenser, considerable reduction has been made in the way of economy. A recent commercial test on an Edison-Hopkinson dynamo of 110 volts and 475 ampères output driven direct by a Willans compound single-acting engine at 430 revolutions, gave a consumption of water of 21.6 pounds per indicated horse-power and 25 pounds per E. H. P. The load was slightly above normal full load.

The successful operation of our ship lighting plants is in a great measure dependent on the ability of the engine to automatically maintain constant speed with varying loads and steam pressure, with either atmospheric or vacuum exhaust, as well as its ability to stand the strain of a heavy change of load. An example of the excellence of American engines in this respect when exhausting into the atmosphere is shown in the following curves taken from a record of the test at Armington & Sims' factory of a two-cylinder 5 by 3 vertical engine, now on board the *Vesuvius.* The specifications allowed a variation of 2 per cent.: (1) On any change of load between total output and 20 per cent. of the same; (2) on any change of steam pressure between 60 and 100 pounds, while exhausting into the atmosphere, and a variation of 5 per cent. (1) On any change between full load and no load; (2) exhausting either into the atmosphere or a vacuum with steam pressure at about 60 pounds.

In the curves shown (Figs. 9 and 10) taken from the test, the load and steam pressure were varied by successive steps and the governing was equally good when working on a vacuum. In addition to this, the entire load could be removed at one step when exhausting into the atmosphere and the engine would not show the slightest unsteadiness. These engines are of the same type as those used for driving the dynamos on board the *Newark* and *Petrel.* A similar engine for one of the dynamos of the *Miantonomoh* was recently tested on a vacuum, the entire load being removed at one step, and the engine showed no tendency to race.

In the French navy the standard lighting plants are slow-speed, compound-wound 70-volt dynamos, driven direct by vertical engines, the efficiency of the combination being from 28 to 33 pounds of steam per E. H. P. per hour for an initial pressure of 70 pounds to the square inch. The dynamo adopted most widely in the French navy is the Gramme multipolar machine, though just at present they are returning to the two-pole type, which they consider stronger, equally efficient, and less liable to get out of order. Within the last few years the Desroziers dynamo (Electrician, vol. 22, p. 762), constructed by the firm of Bréguet has also come into use. In this singular machine the Gramme ring is replaced by a flat disk upon which the coils are wound, rotating between field magnets whose polar extensions are parallel to its axis. Two ships, the *Formidable* and *Forbin*, have had 2 years' experience with the Desroziers dynamo, and it is said to have all the good points of other types at present in use in the French navy, and is, moreover, lighter, better ventilated, and efficient.

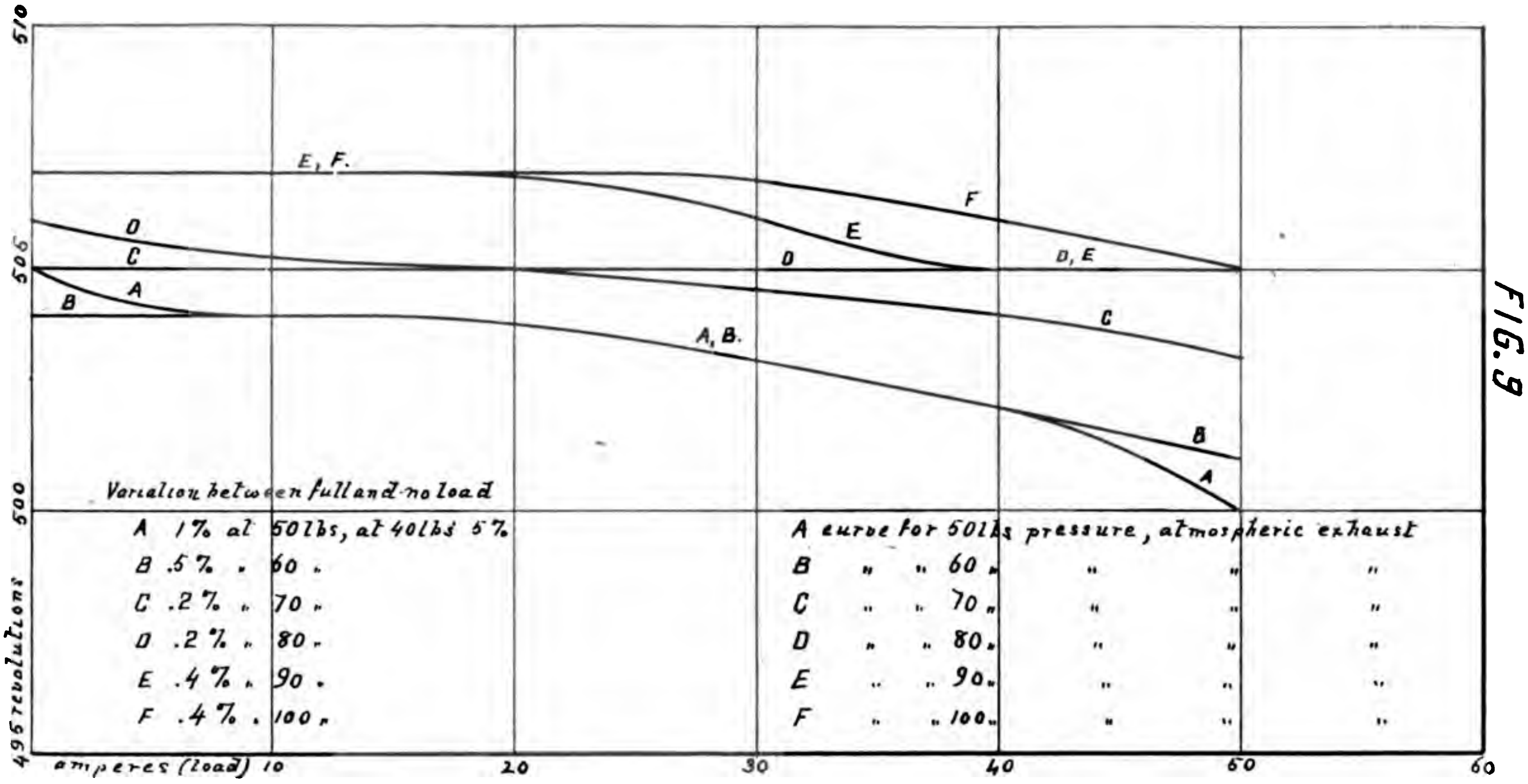

510
506
500
495 revolutions
amperes (load) 10
20
30
40
60
60
E, F.
F
E
D
D, E
C
C
A
B
A, B.
B
A
Variation between full and no load
A 1% at 50 lbs, at 40 lbs 5%
B .5% " 60 "
C .2% " 70 "
D .2% " 80 "
E .4% " 90 "
F .4% " 100 "
A curve for 50 lbs pressure, atmospheric exhaust
B " " 60 " " " "
C " " 70 " " " "
D " " 80 " " " "
E " " 90 " " " "
F " " 100 " " " "

FIG. 9

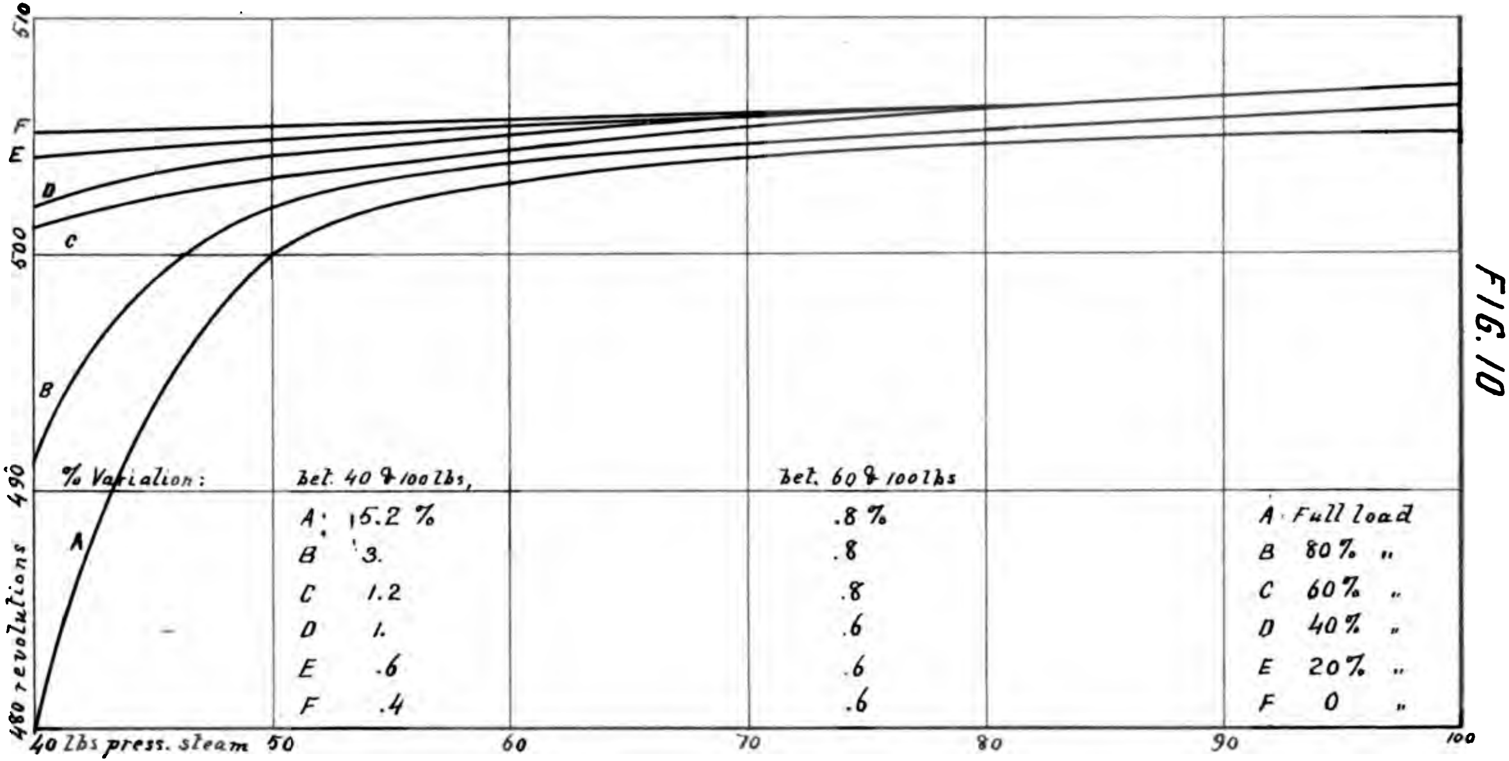

510
F
E
D
C
500
B
490
A
480 revolutions
40 lbs press. steam
50
60
70
80
90
100
% Variation:
bet. 40 & 100 lbs,
A: 15.2 %
B 3.
C 1.2
D 1.
E .6
F .4
bet. 60 & 100 lbs
.8 %
.8
.8
.6
.6
.6
A Full load
B 80 % "
C 60 % "
D 40 % "
E 20 % "
F 0 "

FIG. 10

Recent progress in France has also developed a dynamo which is remarkably light for its output, and requires very little copper. It is known as the Reignier-Bary dynamo. The magnetic circuit has a low resistance, owing to the armature conductor being a compound strip of copper and iron, thus reducing the resistance of the air gap.

The following data on this machine may be of interest:

Peripheral speed, 1,980 feet per minute.
Output, 150 ampères at 70 volts.
Weight of dynamo, 580 pounds.
Output per pound of dynamo, 18.2 watts.
Output per pound of copper, 202 watts.
Output per pound of armature copper, 818 watts.
Electrical efficiency, 94 per cent.
Commercial efficiency, 90 per cent.

In the English navy the current capacity of the dynamos in most general use varies in steps of 100 from 100 to 400 ampères. Their position depends on their number, that is to say, a reserve of power sufficient to work all the important lights must be placed below the water or protected by armor; any additional power can be placed in more airy and convenient places above the water line. This, of course, is the supply usually employed in peace times, the lower or war dynamo room being chiefly, from its necessarily high temperature, used but little except in cases of emergency. If multipolar machines continue to be used in our navy, great care must be observed in their design and location of the dynamo room. The effect on the compass produced by the external field of the dynamo will cause preference to be given to those dynamos having a comparatively weak external field. To accomplish this without making the dynamo heavy, as in some of the recent "ironclad" types, such as the Eikemeyer and Wenstrom, is not an easy problem. Even at the best in some of our smaller vessels the external field, though reduced to a minimum in the construction of the dynamo, will probably be sufficient to exercise some influence on the compass, particularly if the dynamos are near vertical continuous bulkheads; and to save an extra deviation table, the result will be that an electro-magnet (one for each dynamo) producing lines of force in the opposite direction, will have to be introduced in the vicinity of the compass. This arrangement is most undesirable if the effect on the compass can be eliminated by locating the dynamo room at a sufficient distance from the compass, in addition to the use of dynamos of small external field.

The means available that will prevent the compass from being affected by the dynamo are as follows:

(1) Locate the dynamo room as far as possible from the compass.

(2) Make the resistance to the passage of the lines of force through the armature *small* compared to the resistance offered around the armature.

(3) Make the degree of saturation small. In other words, make the armatures long, with plenty of pole face, even at the expense of cost and weight.

Soft iron and plenty of it should be used in the construction of marine dynamos anyhow in order to be sure of obtaining a straight characteristic, even if slightly at the expense of the weight.

(4) The inverted arrangement as shown in the illustration of the Siemens-Belliss combination and suggested by Mr. Willans, is claimed to be one of the best as regards the effect on the compass, not only because the poles are turned downwards, but because they are buried within the cast-iron bed plate.

The advantage of this arrangement lies only in the fact that the bed plate tends to collect certain lines of force of the stray field which would otherwise tend to magnetize bulkheads or directly affect the compass needle, the magnetic leakage of the dynamo being in no way diminished.

Magnetic leakage is objectionable on board ships not only on account of the liability of affecting the compass, but also on account of diminishing the efficiency of the dynamo; the large proportion of lines of force that pass around the armature instead of through it, requiring a proportionately large amount of energy for magnetizing the field. Hence in designing the marine dynamo it would seem preferable to keep the pole piece removed from the base, bearings, etc., and rely on the design being such as will produce small external field in any direction, the result being attained by reducing the resistance of the air gap, and thus possibly save the excessive weight that would be necessary if the iron-clad type were adopted.

The field should be a single magnetic circuit (whether the machine is bipolar or multipolar) rather than the consequent pole type, because the former is more economical in wire and energy of magnetization. In other words, the lines of force should remain undivided through the field cores and pole piece.

Recent observations with the steering compass of the U. S. S. *Concord* resulted as follows:

1.5 = force of ship alone in terms of earth's horizontal force as unit, with one dynamo running.
1.4 = force of ship, etc., with dynamo at rest.
1.5 = 150 per cent. of earth's horizontal force.
1.4 = 140 per cent. of earth's horizontal force.

10 per cent. of earth's horizontal force = increase due to effect of dynamo. These values are, however, subject to revison, being dependent upon the accuracy of the observations. Each dynamo is of 8,000 watts output, of the Edison marine type, and distant 34 feet from the compass.

Regarding the commutator and brushes, one of the recent English admiralty requirements is for the brushes to be arranged on the commutator, three on one side and two on the other, so that the whole surface of the commutator bars is equally covered.

In some recent dynamos, both at home and abroad, the copper brushes are made of gauze and are said to give good results.

The effect on the compass due to the field created by current in a neighboring wire can be prevented by well-known means, viz.: The use of the two-wire system, leads close together, and care taken to keep

EXTERNAL CHARACTERISTIC

F_2 "VICTORIA", 300 amp.

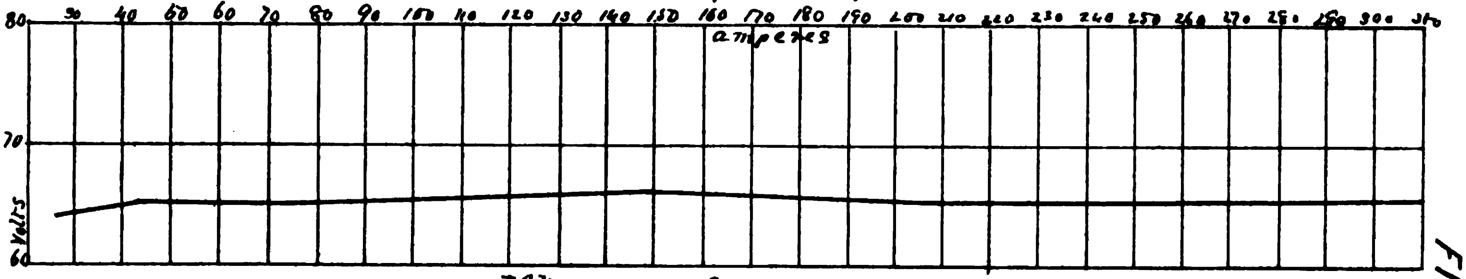
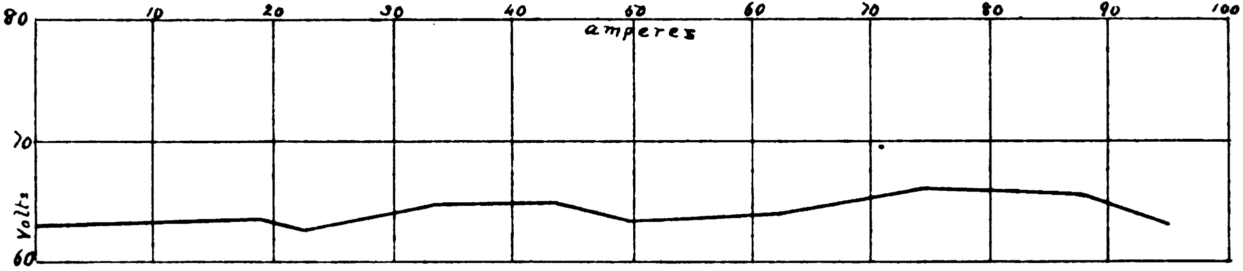


FIG. 11

rev	a	v.
251	25	64
253	42.6	65
252	72	65
253	146	66
249	205	65
252	256	65
250	310	65.5

EXTERNAL CHARACTERISTIC
D_2 "VICTORIA", 100 amp.



rev.	a.	v.
300	0	63
295	19	63.7
295	22.3	62.8
295	33.2	65
295	43.5	65
295	49.8	63.4
295	62	64
295	74	66
295	87.5	65.3
290	94.7	63.3

FIG. 14

the current the same on both poles of the circuits, together with the use of superior insulation.

With the one-wire system, which is still, very generally used in the English merchant service, the compass may of course be easily affected. The advantages claimed for the latter system are simplicity, fewer attachments required, and that it is easier to protect the single wire by an armored casing than is possible in the other case of the double wire.

In the Italian navy they have adopted for general use the Victoria dynamo of the Schuckert-Mordey design (four poles), manufactured by the Brush Engineering Company, London. With the exception of the *Dogale*, *Piedmonte*, and one or two other vessels where special plants of other designs are in use, the generating sets adopted for the Italian Navy are as follows:

Dynamo F_2 Victoria, 300 ampères, compound wound for 65 volts, at a speed of 250 driven revolutions, driven direct by a vertical two-cylinder engine, Raworth coupling.

Dynamo E_2 Victoria, 200 ampères, compound wound, 65 volts, 300 revolutions, direct driven, vertical two-cylinder engine, Raworth coupling.

Dynamo E_2 *bis* Victoria, 150 ampères compound wound, 65 volts, 300 revolutions, direct driven, vertical two-cylinder engine, Raworth coupling.

Dynamo D_2, Victoria, 100 ampères, compound wound, 65 volts, 300 revolutions, direct driven, vertical one-cylinder engine, Raworth coupling.

These four-pole dynamos have each two brushes, 90 degrees apart.

Dynamo P. G. (Pacinotti Gramme). There are two types of this dynamo, one is series-wound, for use, with one search light only, 50 volts, 50 ampères, the other is shunt-wound and used for incandescent lighting only. Nearly all the small vessels of the Italian navy are supplied with the series type only, a few being supplied with both types.

The external characteristic of the 300-ampère machine (Fig. 11) shows how near one of these generating sets comes towards producing the ideal characteristic.

Figs. 12, 13, and 14 show the characteristics of the 200, 150 and 100 ampère generating sets.

WIRING.

Granting that the double-wire system is preferable for men-of-war, the next question is how to divide the lights on the different circuits; in other words, what shall be the arrangement of the wiring? To solve this problem let us consider what will most likely happen to the installation when the ship goes into action. The greatest injury that is likely to occur in the early part of an action is the destruction of any circuit that happens to be above the protective deck, or unprotected by armor. Let us see what happens if a shot strikes one of these unprotected circuits: If the section switch in the dynamo-room be closed, the lamps on that branch if in use will not only be extinguished (unless they are at the same time fed through other mains), but being in an unprotected position the wires will most likely make a short circuit, whether the lamps are in use or not, especially if it is one of the upper-deck circuits exposed to moisture. There will be no chance to make repairs instantly, and the interconnecting of circuits and interposition of safety fuses will only serve to lessen the number of lamps placed *hors de combat*, for the safety fuses will go one after another as long as the short circuit continues. The cut-out nearest the short circuit should go first theoretically, but this can not be depended upon unless the contacts are kept scrupulously clean and the fuses properly proportioned; so that a short circuit in a branch may cause the cut-out in the mains to go. For this reason, as well as the liability of unprotected mains themselves to be short circuited, the leading principle in wiring should be to have the vital parts of the ship, such as the engine and fire rooms, magazines, shell hoists, etc., on mains of their own, with no submain or branch wires leading into unprotected places. And, besides, when going into action greater assurance is given that only the necessary lights are in use.

The fighting circuits being independent of all others, their mains and also those of the other circuits should be interconnected as much as possible and every other possible precaution taken to prevent an important part of the ship being placed in darkness and confusion, and also to allow of an even distribution of light. Now should a shot strike one of the fighting circuits, that branch will be opened and the light for that branch shut off unless fed through another main, but the chances are small that this injury will cause a short circuit unless the fault happens to be in a compartment that has become filled with water. Let us suppose however, the engine room mains become short circuited in action. Until that short circuit is cleared the engine-room lamps supplied by those mains will be extinguished, and no arrangement of wiring, save that of separate mains from the dynamo-room to each lamp, will prevent this. Then, again, should the steam supply fail, even if accumulators are at hand, ready to be switched on, there is bound to be an interruption of the light for at least a short interval. To prevent such an occurrence due to an accident to the steam supply or generating sets, the accumulators should be thrown in parallel with the dynamos, on going into action. For the above reasons, if for no others, a few oil lamps or candles will have to be lighted for the important stations of the ship when going into action.

The principle of having the fighting circuits independent of all others being once adopted, care should be taken to keep all leads of whatever description as much as possible below the water line or armored deck. The system of wiring the *New York* will be in accordance with this principle. The arrangement adopted is shown in Fig. 15.

The Electrician of February 13, 1891, gives a general idea of the system of wiring employed in the French navy, where it would seem that, although the fighting and unprotected circuits are independent of each other, the whole arrangement is too complicated, and the number of

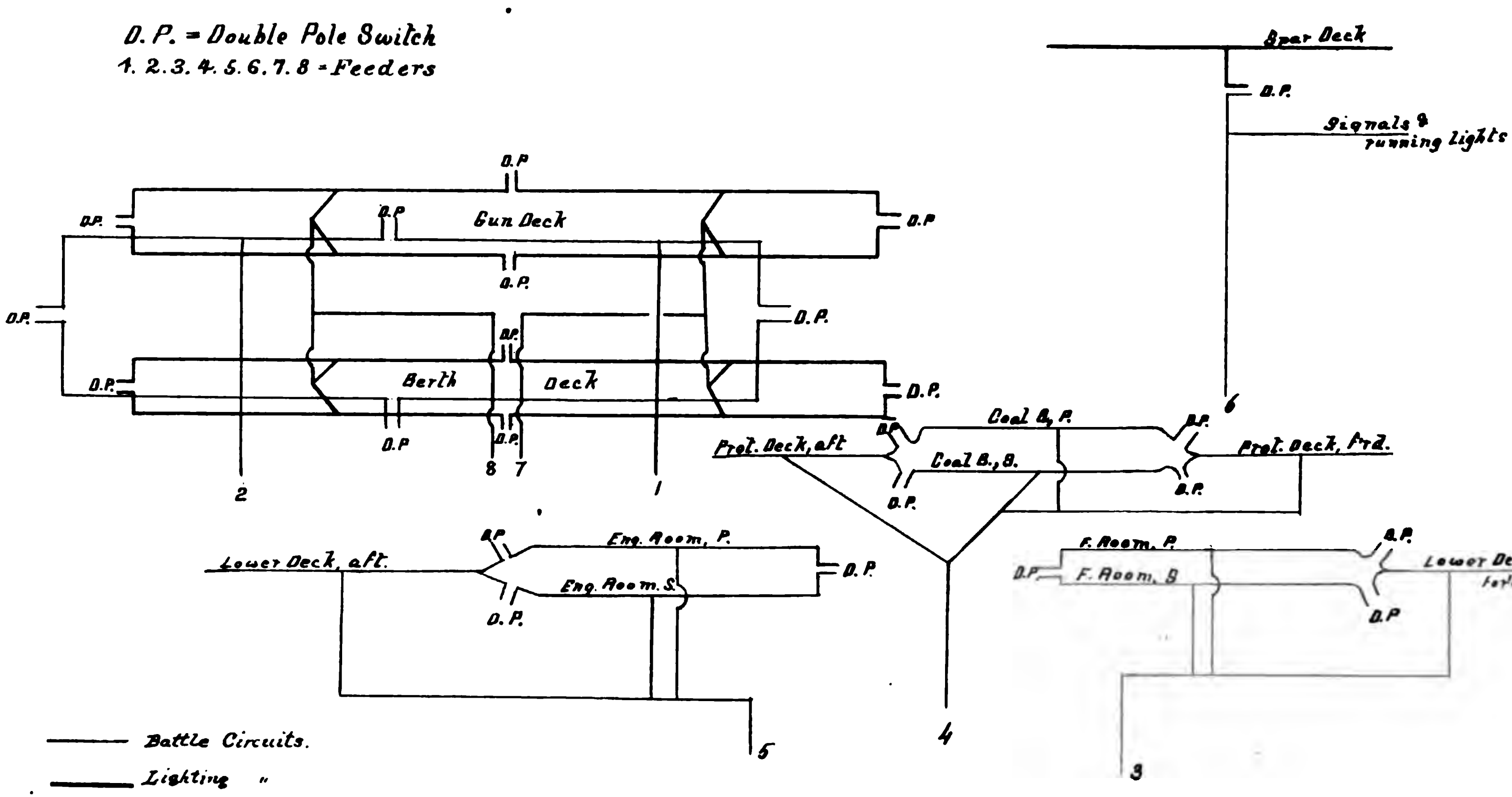

D.P. = Double Pole Switch
1. 2. 3. 4. 5. 6. 7. 8 = Feeders
Spar Deck
D.P.
Signals & running lights
D.P
Gun Deck
D.P.
Berth
Deck
D.P.
Coal B., P.
Coal B., S.
Prot. Deck, aft
Prot. Deck, Frd.
F. Room, P.
F. Room, S
Lower Deck frd.
Lower Deck, aft.
Eng. Room, P.
Eng. Room. S.
1
2
3
4
5
6
7
8
Battle Circuits.
Lighting "

FIG. 15

circuits could very properly be reduced. Then, again, both dynamo-rooms are below the protective decks, the English plan being more sensible where the principal dynamo-room is below the water line and the smaller dynamo-room for ordinary purposes above the protective deck.

The French system is described as follows:

> The one great aim is to so arrange matters as to prevent anything like a complete breakdown of the light in action. To attain this supreme object the port and starboard circuits are all joined across at intervals by connecting cables, so that when any portion of a circuit is damaged the lights are still supplied with current. The electric lighting system is divided into two main divisions, viz, the internal lighting and the external lighting. The *internal* installation comprises—
>
> (*a*) The all-day circuits, viz, those lighting the coal bunkers, passages, men's quarters, etc., in short all those portions of the ship into which daylight never penetrates.
> (*b*) The night circuits, which include all parts where daylight penetrates.
> (*c*) The sea circuits, engine room, etc.
> (*d*) The fighting circuits, including turrets, shot hoists, magazine, etc.
>
> The *external* installation comprises—
>
> (*a*) The projector circuits.
> (*b*) The signal circuits.
> (*c*) The running light circuits.
> (*d*) The miscellaneous circuits.
>
> The internal system is moreover divided into starboard and port circuits. The generating plant is usually divided into two groups, arranged under the protective deck, one forward, the other aft. Each group is joined up to a special distributing board and these in turn are joined to each other. Hence it is possible to run the forward machines and manipulate the circuits from the other board, and *vice versa*, and matters are so arranged that any dynamo can be connected to any circuit. The arc and incandescent lights are run in multiple, and experience has shown that the switching in and out of the protectors does not materially affect the internal lighting.

The following extract from abroad is illustrative of the tendency to se all possible means to prevent a complete breakdown of the impor-ant lights in action:

> The *Admiral Nakimoff* is the first Russian battle ship lighted throughout by elec-icity. The installation was set up by the Jablochkoff Company and consists of four mpound wound 65-volt, 320-light Gramme dynamos, driven by four separate engines. he engines working each pair of dynamos are connected by separate steam pipes both the main and auxiliary boilers. Each dynamo can be switched on to any rcuit at will, and each pair of dynamos can be connected in parallel arc. The mains m three circuits are connected to the main switchboard. Two of these circuits pply the gun and main decks, one pair extending along the port side of the gun ck, descending at the bows to the main deck, thence led aft along the whole length the port side of the main deck, and ascending at the stern to the gun deck, where respective conductors join and thus form, each, a complete circle. The second ir of conductors travel along a parallel path, but on the starboard side of the sel. The third pair of conductors supply the engine-rooms, stoke-holds, and maga- es. The corresponding mains of the port and starboard circuit on the gun and in decks can be connected together at the fore and after part of the ship by means switchboards, to which they are connected by supplementary conductors. The hts on the fore and after orlop decks are regulated by auxiliary switchboards, so t they can be fed direct from the dynamos, or in case of need from 150 accumula- s on each deck.
>
> he advantages claimed for this system of lighting on war ships are that the lay- of the conductors on the gun and main decks in an annular path prevents the

extinction of any lamp in the case of a single injury causing the severing of one of the conductors by an enemy's shell, as the mains will be still connected at the ends to the dynamo. By joining the circuits at the fore and aft switchboards, even the total severing of one pair of conductors leading to the main switchboard would not cause the extinction of any lamp. Moreover, the orlop decks, where the chief engines of war are situated, being supplied either by accumulators or the dynamos, their illumination can be cut off only by the destruction of the decks themselves.

The writer of the above extract forgets that no matter whether the orlop lamps are supplied by accumulators or dynamos, if their mains should be short circuited nothing can prevent the lamps being extinguished. Not that this is very liable to happen, but if the continuous supply of light to these places is to be insured, a few oil lamps are absolutely necessary. The most that accumulators can do is to maintain the feeding of the electric lights in case of injury to one of the generating sets or a failure to supply steam.

As regards the time for beginning work on the ships' installations, experience with our vessels has shown that the proper time for beginning work on a ship building, is about the time the boilers are placed on board, whether the ship be on the ways or in the water; for at this time the work of wiring, means of interior communication, etc., can be done to the best advantage, and at the same time the ship, when finished, will not be delayed on account of her electrical equipment.

Apropos of this, is the following extract from the Electrician as illustrative of the experience abroad:

In the forthcoming navy estimates, says the Portsmouth correspondent of the London Times, a sum of money will be asked to provide an important and much needed improvement in Portsmouth dockyard. The work below decks in ships after being launched is comparatively slow in consequence of the obscurity in which it is carried on. When the work in progress is so far advanced towards completion that the steam power of the ships can be brought into requisition, or where ships are docked for repairs, it is customary to make use of electric lamps. But it is obvious that in periods of emergency, when it would be of paramount importance to get ships ready with the utmost dispatch, the work of preparation would have to be continued throughout the night and with all speed. It is now proposed to erect central electric stations in connection with the various docks and basins, so that ships repairing, refitting, or completing for sea may be brought close at hand and their own wires connected with the stations.

CONDUCTORS.

The size of conductors on board ship, as elsewhere, is governed by the fact that they must be able to carry the maximum current for that circuit without heating above a certain temperature, and of such resistance that the drop will not be more than the amount allowed. The heating of conductors above the safe limit is objectionable for three reasons: danger of fire, deterioration of the insulation, and increase of resistance of the conductors themselves.

The standard rule with our recent installation for the size of conductors as regards heating alone is 1,200 circular mils per ampère. This rule easily allows all but the largest conductors to carry a current 50 per cent. above the normal without heating above the safety limit, and should double the normal current pass through them the cutouts will protect the conductors; for this purpose safety fuses are inserted wherever there is a reduction in the size of the conductor. As a matter of fact, wherever there is a branch circuit taken off there is placed a junction box containing safety fuses. The above rule of 1,200 circular mils per ampère gives, for some of the smaller conductors, a size greater than necessary for safety, but this is offset by the advantage of having as small a variety of sizes altogether as possible on board ship and also helps to reduce the entire drops between the dynamo and the farthest lamps. In addition to complying with the heating requirements the conductors must be of such a size that, supposing the maximum current carried by any main to flow the entire length of that main, the drop between the dynamo and the farthest lamp will not be greater than 3 or 4 per cent. Following the above rule in calculating the sizes of the mains gives at full load a practical drop of about 2 per cent. between the dynamo and the farthest lamp, depending on the system of wiring employed.

The question arises, what is the limiting temperature to which conductors can be raised without injury? It is placed at 150° F., with double the proposed current, by the committee of the London Institution of Electrical Engineers for the prevention of fire risks, as published last year, for wires run in wooden molding. The only remaining question is the normal temperature of the wires from which the rise is assumed to take place. In a house on shore it will never be as high as in the vicinity of the engines, boilers, or dynamo room of a ship. That the normal temperature is of some importance may be seen from the fact that in the dynamo room of the *Charleston* the temperature has frequently been as high as 135° F. Mr. A. E. Kennelly, of the Edison laboratory, in an exhaustive series of experiments on insulated wires run in molding, has found the temperature elevation to vary nearly as the square of the current. It is impossible, of course, to find a rule that will be applicable to extreme cases. In Mr. Kennelly's experiments the mean normal temperature was taken as 24° C., so that with 150° F. (65° C.) as the maximum limit, the permissible rise, with double the proposed current, was 40° C. The following simple equation was found, which very nearly followed the 40° C. curve.

Limiting current in ampères $=560$ (diameters of wire in inches)$^{\frac{3}{2}}$.

$$
\begin{aligned}
C&=560\, d^{\frac{3}{2}} \text{ if } d \text{ is in inches.}\\
&=.01775\, d^{\frac{3}{2}} \text{ if } d \text{ is in mils.}\\
\text{and}\qquad d&=.0147\, C^{\frac{2}{3}} \text{ if } d \text{ is in inches.}\\
&=14.7\, C^{\frac{2}{3}} \text{ if } d \text{ is in mils.}
\end{aligned}
$$

Or for ordinary purposes it is convenient to remember that when d is expressed in inches and C in ampères,

$$d=\frac{\sqrt[3]{C^2}}{70}$$

From these data the following table is useful; in which, for every one of these conductors, double the corresponding current can be carried with a permissible rise of 40° C. This allowance of 40° C. rise of temperature is somewhat too large for conductors in such places as dynamo room, fire room, etc., but for other parts of the ship it will answer very well.

Ampères.	Minimum safe diameter of copper wire.	Circular mils per ampère.	Fall of potential in wire at full load; volts per foot.
	Inches.		
1	.015	225	.0503
5	.043	370	.0305
10	.069	480	.0237
15	.090	540	.0208
20	.109	590	.0189
25	.126	640	.0177
30	.142	670	.0167
35	.158	710	.0158
40	.172	740	.0152
45	.186	770	.0147
50	.200	800	.0141
55	.213	825	.0136
60	.225	845	.0133
65	.238	870	.0129
70	.250	890	.0126
75	.262	915	.0123
80	.274	940	.0120
85	.285	960	.0118
90	.296	970	.0116
95	.307	990	.0113
100	.318	1,010	.0111
110	.339	1,040	.0108
120	.358	1,070	.0105
130	.377	1,090	.0103
140	.396	1,120	.0099
150	.415	1,150	.00975
175	.461	1,210	.00929
200	.504	1,270	.00887
225	.545	1,320	.00853
250	.585	1,370	.00817
275	.623	1,410	.00798
300	.660	1,450	.00771
325	.697	1,490	.00753
350	.732	1,530	.00734
375	.766	1,570	.00716
400	.800	1,600	.00714
425	.832	1,630	.00692
450	.865	1,660	.00674
475	.897	1,690	.00665
500	.928	1,720	.00652
550	.988	1,775	.00634
600	1.049	1,840	.00616
700	1.16	1,920	.00585
800	1.27	2,020	.00558
900	1.37	2,080	.00539
1,000	1.47	2,160	.00521

Copper resistivity, 1.650 microhms at 0° C.
= 1.870 microhms at 34° C, assumed temperature of full load.
Conductivity allowed, = 98 per cent.

Let us consider the allowable rise of temperature in the dynamo coils. As with other conductors of the installation, we must consider the temperature of the dynamo room, which may be as high as 130° F., and also the maximum limiting temperature of the coil, which latter is the temperature at which the insulation would begin to deteriorate, which is between 150° F. and 200° F.; say 175° F. In order to comply with the specifications, 50° F. is the permissible rise for our marine dynamos. It will thus be apparent that no greater temperature elevation than this should be permitted.

The dynamos for the English Admiralty have to pass two heating tests before acceptance. The first specifies that after running for 6 hours at full load " no *accessible* part of the armature or magnets should have a temperature of more than 20° F. (sometimes 30° F.) above the temperature of the dynamo room." This temperature is taken at the end of 1 minute after stopping, by laying a thermometer on the armature or field magnets and taking the reading. The other test consists in allowing the thermometer to remain on the coils and see how high it will rise in, say, half an hour. 70° F. is the allowable rise, which is evidently much higher than should be allowed, when we consider what the temperature of the dynamo room at times is liable to be.

Lead-covered wire, run in molding, continues to be preferred in our Navy. It has given excellent results, and will no doubt continue to do so. Lead-covered wire has recently been introduced in the English Navy, but in such cases the tendency is to do away with molding, and in some cases to cover the lead with a thin armor of iron.

FIXTURES.

Marked progress has been made during the past year by the Bureau of Equipment, towards making the fixtures for all vessels interchangeable; and the lampholders and fixtures must now conform to naval standards.

INCANDESCENT LAMPS.

The incandescent lamps used in our Navy have, in most cases, continued to give good results. This is due to the fact that the low economy lamps have been adhered to. The lamps supplied the *Dolphin* and *Vesuvius* failed, due to imperfect manufacture. High economy lamps were tried on board the *Chicago*, but with results sufficient to preclude their further introduction in the service. The reason for this is that as we increase the economy of the lamp (less watts per candle) we raise the temperature of the filament and shorten its life. Take a new lamp and run it continuously at its normal voltage; recent experiments by Professor Nichols and Mr. W. H. Pierce show that both the candle power and efficiency decrease with time. Some of Professor Nichols's conclusions from his exhaustive experiment are interesting, and may be quoted as follows:

The efficiency of an illuminant in which carbon is the glowing material is a function of the temperature. It appears that the incandescent lamp is fairly stable only at temperatures for which its efficiency does not exceed about 5 watts per candle. When we attempt to maintain lamps at degrees of incandescence corresponding to a much higher temperature we materially shorten the life, as for instance when an 80 volt lamp is maintained continuously at 80 volts, the resistance of the lamp gradually increases, the current and energy necessary to maintain it at 80 volts is decreased, the candle power gradually decreases, and in greater ratio than the former: the watts per candle increase, the temperature gradually increases, and the life is shortened. Or take a lamp and maintain the normal candle power throughout by raising the potential; the life will be very short. As we gradually raise the potential to maintain the candle power, the efficiency gradually falls (more watts per candle) and the temperature gradually rises.

The principal causes that reduce the candle power are gradual blackening of the bulb, gradual increase of resistance due to disintegration, and gradual diminution of the vacuum.

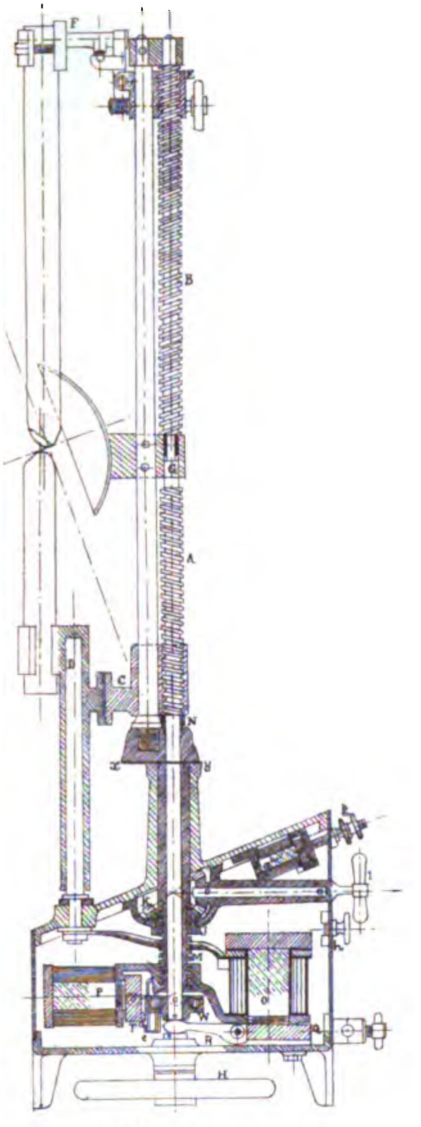
On board ship, however, where, on account of space and weight, it is desirable to supply as little power as possible for the ordinary electric lighting, we can well afford to make a compromise between the life and efficiency of the incandescent lamps; in other words, continue to use lamps of about 4 watts per candle.

SEARCH LIGHTS.

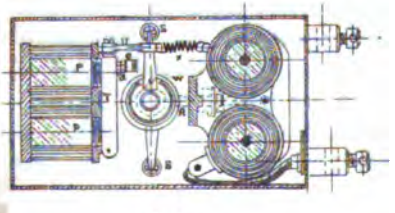
For the larger classes of vessels, it is considered necessary to equip them with a sufficient number of search lights to enable them together to easily sweep the entire circle of the horizon in detecting the approach of torpedo boats. They are also useful in directing the fire of the battery at night, for navigation purposes, and, under special circumstances, such as a man overboard at night, signaling, etc. It is imperative that, as a rule, they should be located as near the water line as possible, in order to cover a large area with a given beam of light, and also to locate them so as not to be injured by the concussion due to the firing of the battery. At least one of the projectors should be placed high up, so as to be effective when long range is required in searching. The latest type of lamp used in the navy is a combination one, either hand or automatic, as desired. It is of the type supplied the *San Francisco*, and manufactured by Sautter-Harlé, & Co., Paris. It is designed for a voltage of 45 to 50. The lamp supplied with the 60-centimetre projectors is designed for 80 ampères or less, and for the 75-centimetre projectors 80 to 100 ampères. In many cases it is customary to mount the projectors on movable carriages, so they will not be unduly exposed except when wanted for use, and when not in use can be run inboard and better protected from the weather or the fire of the battery. The *Concord* and *Bennington* are also supplied with the French type, 50 ampères only being used. A few ships, notably the *Chicago*, *Boston*, and *Atlanta* are still supplied with the old French search-light plants (Brotherhood-Gramme). These plants will soon be replaced, having given long and faithful service. When their dynamos

FIG. 16

ELECTRO-MOTOR LAMP



Elevation



Plan

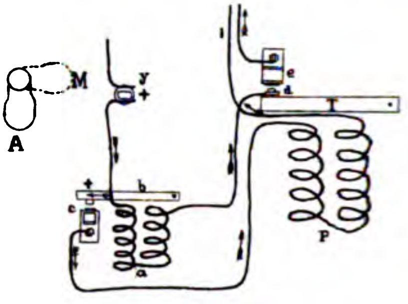
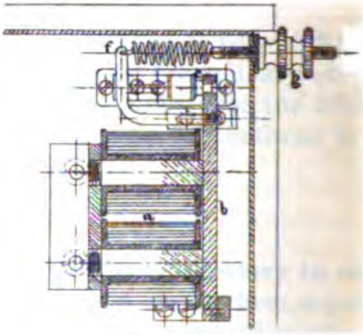
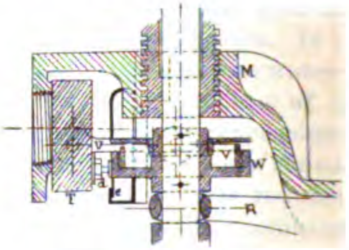


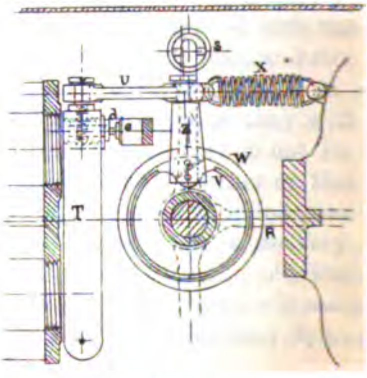
Diagram of Circuits



Plan of Relay



Automatic Regulator. Elevatn



Plan

re working singly the lamps (hand lamps) take 48 ampères at 47 volts,
nd these are the figures quoted by the manufacturers. The search-
ghts of the Thompson-Houston Company (hand lamps), such as sup-
lied the *Baltimore*, *Philadelphia*, and *Yorktown*, are designed for 50
mpères and 50 volts.

In this connection it may be worth while to note that generally with
he arc light, the size or area of the crater is a rough measure of the
urrent strength, but the latter varies with the quality of the carbons.
Vith an arc lamp that operates with 45 volts potential Professor Fleming
as recently shown that the difference of potential between the positive
arbon and the arc flame is about 40 volts, and the few volts which ex-
ress the difference between the flame and the negative carbon make
p the total potential, say, 45 volts.

In operating arc lamps in parallel on a constant potential circuit,
wing to the fact that the resistance of the arc decreases with an in-
rease of current, it is necessary to insert a resistance in the arc branch
nd raise the potential to 65 or 70 volts. Under these conditions, with
resistance taking up 15 to 20 volts in series with the arc, it may be
run in multiple with incandescent lamps or with other arcs.

The modern automatic French lamp, which, by the way, is independ-
ent of gravity, and which is similar to those on board the *San Fran-
isco*, may be described as follows (Fig. 16):

The automatic lamp for projectors is composed essentially of two
screws, A and B, one with right-hand thread, the other with left, and
the amount of pitch being proportional to the consumption of the pos-
tive and negative carbons. Upon each is mounted a nut, E, N, carry-
ng, respectively, the positive and negative carbon holders. The two
crews A and B are fitted to the special coupling G in such a manner
hat on turning it to the right the carbons will approach each other and
f turned to the left they will be separated. This movement can also be
btained by moving by hand the wheel H.

On the prolongation of the screw A is keyed a bronze box, W, in the
nterior of which is placed a beveled split ring. A lever, Z, carrying
wo pins, permits—

(1) Of connecting the two edges of the split in the ring V.

(2) Of separating them.

In the first case the exterior diameter of the ring V is diminished,
d the ring is free to turn in the box W.

n the second case the exterior diameter of the ring V is increased,
its exterior surface bears against the interior of the box W,
ich is obliged to follow the movement of the lever of the ring

The lever Z is joined by a small rod, U, to the armature T of
ine-wire electro-magnet P, connected in multiple with the two
minals of the lamp. A relay, *a*, sends at the right time a cur-
t into the electro-magnet P by way of the contacts *b* and *c*. A
ing, X, whose tension acts in a direction against the electro-magnet,

brings the armature to the initial position. The electro-magnet *a* of the relay is of equally fine wire and in multiple with the arc. Its circuit is closed by a contact, *d e*, placed on the armature of the electro-motor P only when it is at its initial position. The circuit of the relay is broken when it leaves that position. A spring, *f*, placed on the armature of the relay acts in an opposite way to the electro-magnet; it can be held in more or less tension by means of a small screw and thumb nut, *g*, placed on the outside of the lamp. A commutator, Y, is connected with the circuits of the two fine-wire electro-magnets, and permits the breaking of the circuit when it is desired to work the lamp by hand. In this connection it will be noted that it is always necessary in this case to break the current in the electro-magnets by placing the handle of the commutator on the letter M before moving the wheel H. The arc is struck automatically by an electro-magnet, O, interposed in circuit, which at the instant of the current passing attracts its armature and gives, by means of the lever R, a downward movement of the whole lower carbon-holder system. The exact placing in the focus in the vertical direction is made as in the ordinary hand lamp by a wheel, *i*, which works by means of a pinion, *k*, both the carbon holders. A white line engraved on the sleeve M indicates that it is in the mean position, when it is in the plane *x y* of the sleeve of the outer surface plate of the lamp.

The working of the lamp is as follows:

Turn the commutator on the mark A. The current passes in the fine-wire electro-magnets. The electro-magnet *a* of the relay attracts its armature and makes contact between the two points *b c*, closing in consequence the circuit of the electro-motor P, which in its turn attracts its armature, drawing in its movement the lever Z, and in consequence the ring V and its box W keyed on the screw of the two carbon holders. The latter, turning in the interior of nuts E and Y, cause the carbon holders to advance towards each other by a small amount. At the moment the armature T of the electro-motor is attracted it breaks contact at *d* and *e* and breaks the circuit of the relay *a*, of which the armature, yielding then to the spring *f*, is returned to its initial position, breaking in its turn in this movement the circuit of the electro-motor P, whose armature under the action of the spring X is returned then to its initial position, closing again in this movement the circuit of the relay *a*, which attracts its armature, sends a current for the second time into the electro-motor P. This vibrating movement continues until the carbons are brought together. At this moment the striking electro-magnet functions and the arc is "struck."

The regulating of the lamp consists in giving to the spring *f* of the relay a tension such that the attractive force of the electro-magnet *a* will overcome the spring f, for a potential at the terminals of the lamp of 45 to 50 volts, suitable to maintain an arc in its best condition.

By turning the button in the direction of the arrow R, we distend the spring and augment the frequency of movement of approach. We do the contrary by turning it in the direction of the arrow E.

To work the lamp by hand, turn, as we have said, the commutator on the letter M, then work the wheel H by hand.

It may happen that when the commutator is turned on the letter M we would find some difficulty in turning the carbons by hand. This shows that the ring V has been strained or bent by some straining manœuvres or that the spring X itself has been slightly distended. In the first case the box W must be dismounted and the ring V repaired; in the second case, it suffices to cut a spiral from the spring X or change it. The dismounting of the box W is accomplished as follows: Raise the little rod U and the spring X, the abutment pier of the upper carbon holder and the support of the screen, the pin that holds the indented pinion K on the carbon-holder screws; take out the pins which hold on this rod the washers of the abutment pier and the pawl box W.

Remove from the guide simultaneously the two carbon holders and the rod which unites them, until the box W is free from the end of the rod A. The box W is free; we can inspect the interior.

The very latest improvement in search lights abroad is that which allows them to be manipulated from a distance, on constant potential circuits. Not only is the lamp automatic, but motors are attached for training, both horizontally and in elevation. In this way one or more projectors are electrically controlled, one man only being required who would be stationed in the conning tower or other convenient protected place. The search lights of the *New York* are to be fitted in this way, and 30-inch (75-centimetre) projectors will be used. With projectors of 60 centimetres diameter, the current may vary from 45 to 80 ampères as desired. With the 75-centimetre projectors, Sautter-Harlé & Cie. allow a current of 80 to 100 ampères. The projectors also admit of using hand power, either at the projector or a short distance away through the intervention of rods. The movement of training can be either continuous (which would be desirable when expecting a night attack) or by small angles, as when searching with a concentrated beam when long range is desirable. Another improvement has recently been made by Sautter-Harlé & Cie, in which the plain lens is done away with and instead the projector is fitted with two diverging lenses of such a character as to permit at will of a variable divergence to the beam. One of the lenses is fixed, the other movable.

In one of the extreme positions (with the 60-centimetre projector) the angle of divergence does not exceed 2 degrees; the beam is then identical with that which the closed projector gives with a simple plain lens. The illuminated zone at 1,000 metres distance has a width of 35 metres. In the other position, the dispersion is 20 degrees, and the illuminated zone at 1,000 metres distance is 350 metres wide; the rotation of a wheel moves the lens longitudinally so as to procure the intermediate positions. Generally speaking the former extreme position of the diverging lens would be used in searching at long range, and the latter when sweeping rapidly for defense when long range is not required, but, by instead, great divergence and a quickly moving beam.

The 60-centimetre projector, with the lamp taking 75 ampères and the beam concentrated, should give a range of 2 to 3 miles; that is, should make light objects plainly visible at that distance on dark nights (no fog or mist).

Such projectors as are located on the berth deck so as to be near the water line are rigged out through a port when desired for use, and when not in.use are rigged in and the port closed water-tight.

MEASURING APPARATUS.

The Sivertown testing set is the apparatus at present supplied to our war ships. Its field of usefulness is somewhat restricted owing to the nature of the apparatus. In view of the extent of the electrical appliances in a modern man-of-war, it seems as if an apparatus should be installed which would allow of the necessary electrical measurements being made at any time, at sea or in port. The best galvanometer for this purpose is the Thompson marine galvanometer. This, together with a few resistance boxes, battery, standard condenser, Clark cell, etc., will allow of accurately making all the necessary measurements that would ever be required to maintain the electrical equipment of the ship in an efficient condition. In the English navy every vessel that is allowed a torpedo officer is supplied with one of these marine galvanometers set up in the electrical storeroom.

The principal measurement required on board ship is that for insulation. Not only must the insulation of the conductors themselves be first class, but also that of the lamps, junction boxes, fuses, switches and fixtures; as most of these latter are supposed to be water-tight, no great allowance can be made on their account for the insulation of the entire system, and the insulation resistance of a spar-deck circuit should consequently be high, even on a wet day.

On shore, however, where as a rule the connections are not supposed to be water-tight, the insulation of the outside circuits is greatly dependent on the state of the weather, and nothing but practice and experience in the behavior of machines and lamps, as well as the behavior of the instruments when the test is being taken, together with the state of the weather, can enable one to judge with accuracy whether a fault exists in the circuitor whether a low reading or succession of low readings is caused by surface leakage at switches, fuses, or lamps, or in the case of arc lamps, even over the surface of damp globes. The same thing is applicable on board ship, though in a less degree.

The faults that occur in the insulation of the lead-covered conductors are generally traceable to either (1) “pinholes” gradually developing in the lead covering under the action of the leakage current, due to defects in manufacture, or (2) mechanical injury.

Conductors that are not lead covered are liable to have their insulation affected also by vermin, abrasion, dry heat, and salt water. A spare armature, for instance, unless kept in a dry place, is liable to go up in a blaze the first time it is tried. The combined action of oil and heat on dynamo coils will soon render them useless.

Whatever standard of insulation resistance is adopted for marine installations should depend on the voltage and number of outlets, and the figures are of no value unless it is stated with what battery power the result was arrived at. Neither should the standard be as high as it otherwise would be were it not for the fact that in some of the compartments of a ship the fixtures are not required to be water-tight, for in these cases there must be times when they are exposed to a damp atmosphere, thus lessening the insulation of the entire system. In dry weather the insulation of each section will vary inversely with the number of outlets in that section, though practically in a less proportion.

The insulation resistance of the entire installation (420 outlets) of the *San Francisco* was found to be 93,000 ohms, or nearly five times what would be required by Professor Jamieson's rule. A good standard for marine installations would be a modification of Professor Jamieson's rule as follows:

$$R=\frac{300,000\times E}{N}$$

N being the number of outlets, and a battery of 10 or 12 volts being used for testing, with marine galvanometer. This standard should easily be attained whether the rule is applied to the whole or a part of the installation, particularly if the exposed fixtures are water-tight. Section No. 2 in the *San Francisco* contains 48 outlets and measured 860,000 ohms. The above formula would require, for acceptance,

$$R=\frac{.3\Omega\times 80}{48}=500,000$$

ELECTRIC MOTORS.

The Forges et Chantiers de la Méditerranée are making great use of electrical power, not only in their Toulon shops, but for working the Canet 15-centimetre quick-firing gun. For training in elevation a small electric motor is placed on a bracket bolted to the rear of the left-hand frame of the carriage and forming an extension of it; the armature runs on a horizontal shaft. On this is mounted a bevel wheel that gives motion to suitable gearing and to a spindle that actuates the elevating gear. For training horizontally a second small motor is employed. In both cases a clutch is interposed in such a manner that by shifting a lever the electrical arrangement can be thrown out and the ordinary hand gear substituted. The motor that supplies the energy for training in elevation weighs 61.6 pounds; that for training in direction, 72.6 pounds. The difference of potential adopted is 70 volts, which is the standard in use in the French navy for electric lighting. It is more convenient to work them with the same energy of current for each motor and to insert resistances in the circuit of the motor used for elevating the gun.

At the Paris Exhibition, where an electrically equipped Canet quick-firing gun was exhibited, recourse was had to accumulators, they being of the same type (Desmazures) as were used in the French submarine torpedoboat *Gymnote*, and which were described in General Information, Series No. VIII. Especially interesting in this arrangement is the facility given for training both in direction and elevation at the same time, as it is obvious that the work of laying the gun can be carried out far more promptly and the rapidity of fire can be thus largely increased. One man trains or elevates with his left hand and fires with his right.

During the past year the Ordnance Bureau of our Navy Department have successfully applied a Crocker-Wheeler electric motor to the firing of a Gatling gun. The advantage of having the same man sight and control the firing of the gun is obvious.

Two arrangements are worthy of notice that have been utilized by Lieutenant Fiske for the working of guns both in elevation and in training. In the first arrangement the gun is controlled by two motors, C and D (Fig. 17), one for raising and lowering the breech, the other for training, both being accomplished by the same lever, E, with a spherical joint, M, and guided by two crossed grooves, u and u.′ When we raise or lower the lever E (Fig. 18) the groove in u allows the ratchet S to turn the commutator in a direction so that the motor C raises or lowers the gun. This rotation of the motor restores of itself the commutator, the ratchet S, and lever E to their neutral original positions in such a manner that the gun stops of itself after having pivoted to an angle proportionate to that of the movement of the lever.

At the same time, when the lever E is displaced to the right or left it works in the groove of u and controls by the ratchet S′ the commutator of the dynamo D.

Fig. 19 shows a modification, permitting of executing all the movements of pointing by means of a single dynamo, F. The screw *b* raises or lowers the breech of the gun as the lever E rises or falls, by P and O, and the wheel C makes the gun turn in the direction following it according as the lever is lowered or raised by u u′ and B R.′

A description of the two motors applied to one of the 8-inch guns of the *Chicago* (one for training and the other for elevating), as well as the motor for the ammunition hoist of the *Atlanta*, will be found in an article by the writer in the Electrical World of February 7, 1891.

The tendency of late to adopt electrical in place of hydraulic power

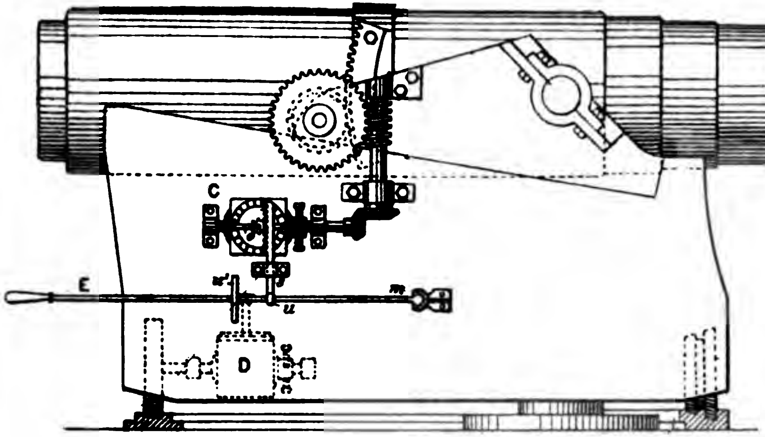


FIG. 17

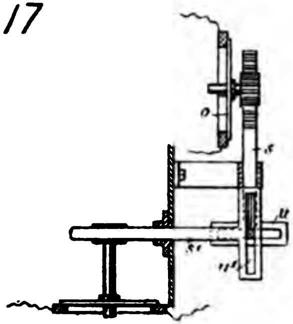


FIG. 18

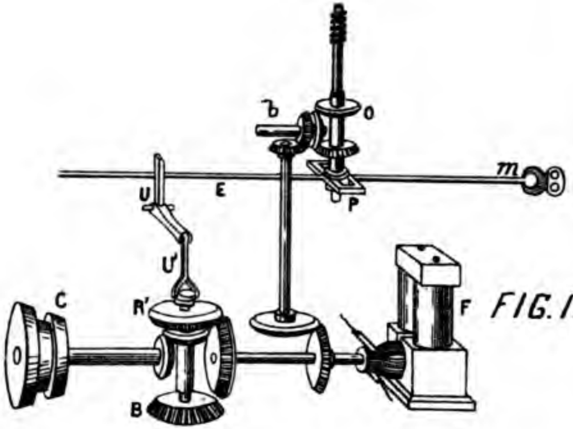


FIG. 19

for working guns is shown in the equipment of the *Captain Prat*, one of the Chilean ironclads recently built by the Forges et Chantiers de la Méditerranée. In this ship not only the rapid-fire-guns but the main battery are worked by electric power. The four 24-centimetre guns are installed in barbette turrets; these guns are worked by hand or electricity. The 12-centimetre guns, eight in number, are rapid-fire; they are mounted on special carriages, which can be manœuvred by hand or by electricity with great rapidity and precision. In this ship electric motors are also utilized for hoisting ammunition to the tops and for the ammunition hoists that supply the 24-centimetre guns. The tendency is to utilize electricity also for the firing of all guns, as by this means the actual firing is more nearly instantaneous with the desired moment. As an example, the 47-inch Armstrong rapid-fire guns now fitted to the auxiliary battery of the *Trafalgar* are fired by electricity, the mechanism for that purpose being simple and ingenious. In the base of the cartridge case is screwed an electric primer, against which an insulated steel pin, carried in the axis of the breech-block, presses. This pin is in communication with the electric wires, which carry the current to fire the primer only when the breech-block is closed and secured by turning the lever downwards against the rear of the block. The circuit is closed and the charge fired by pulling the trigger of a pistol handle, arranged in a convenient position close to the sights. In case of failure of the electric firing gear, each gun is also fitted with an independent percussion lock.

Electric motors for driving ventilating fans, are used in our service and also abroad.

In the French Navy electric drills are a part of the equipment of vessels, and on board the *Formidable* they have been of great value. The opinion is held in France that the adaptation of electric motors to pumps, hoists, and winches, is only a question of time, and that little by little we shall see the complicated, inefficient, and cumbersome hydraulic and steam pipes disappear from battle ships.

Some trials were had at Portsmouth, England, on February 10, 1891, of a 6-inch rapid-fire gun. Electric firing was used throughout the trials, and not a single misfire occurred in the 100 rounds. There was tried on this occasion for the first time a special arrangement for testing the electric firing circuit and primer. This was done by means of an instrument which is fitted on the electric firing pistol, and gives forth a ringing sound whenever the circuit is complete. This information would be conveyed at once to the firing gunner if everything is correct before he attempts to fire. The instrument also provides a means of warning whenever the gun is loaded, and thus is dangerous to approach within the limit of range or recoil. The very exhaustive trial of firing the 100 rounds in rapid succession proved that the little instrument did its work thoroughly, without being in the least disturbed by the shocks.

SECONDARY BATTERIES.

It is understood that accumulators or storage batteries now form a regular part of the equipment of many of the vessels of the English navy, they being used to supply the extra power necessary for working the electric gear of the guns when the dynamos are otherwise already working up to their full load or nearly so. It is presumed they will also be used for the gun-firing circuits, and for such other work as is at present being done on board ship by primary batteries. The writer has found no evidence of any marked improvement during the past year as regards the weight of storage cells generally for a given capacity.

COMMUNICATION.

The subject of an efficient and rapid transmission of signals has engaged the attention of the Department for some time past, and nothing is of more importance in the development of our new Navy than an efficient signal service. The incandescent electric light seems well adapted for the transmission of night signals over moderate distances, so much so that signaling at night bids fair to be accomplished more rapidly than by day. After investigating the different systems abroad in which electricity is used the system of Captain Ardois seemed to commend itself, and six sets were purchased from the manufacturers, Sautter-Harlé & Cie., for use in the squadron of evolution.

ARDOIS SYSTEM.

Captain Ardois's system is very simple and admits of rapid working. Its characteristic feature consists in having all the indications of the signals inscribed on the apparatus itself, on a dial plate; the construction being such that it suffices, in order to make a signal, to bring the pointer of the manipulator opposite to the indication of the signal to be made.

The apparatus complete is composed of—

(1) Lanterns, containing lamps.

(2) A multiple cable.

(3) A key-board.

This system has been installed on board the *Pelayo*, a first-class cruiser in the Spanish navy. The apparatus now being tried in the evolutionary squadron is similar to that on board the *Pelayo*, or nearly so, the dial of the key-board being specially marked to meet our requirements.

Lanterns.—The number of lanterns employed is five. These lanterns each contain two lenses (Fig. 20), one red and one white, one above the other, each provided with a 32-c. p. 80-volt lamp placed in the focus. The carbon filament has three loops, and the light is concentrated in a small bulb. By varying the number and order of the illuminated lanterns we can make 62 different displays, distinctly visible at a considerable distance.

FIG. 20

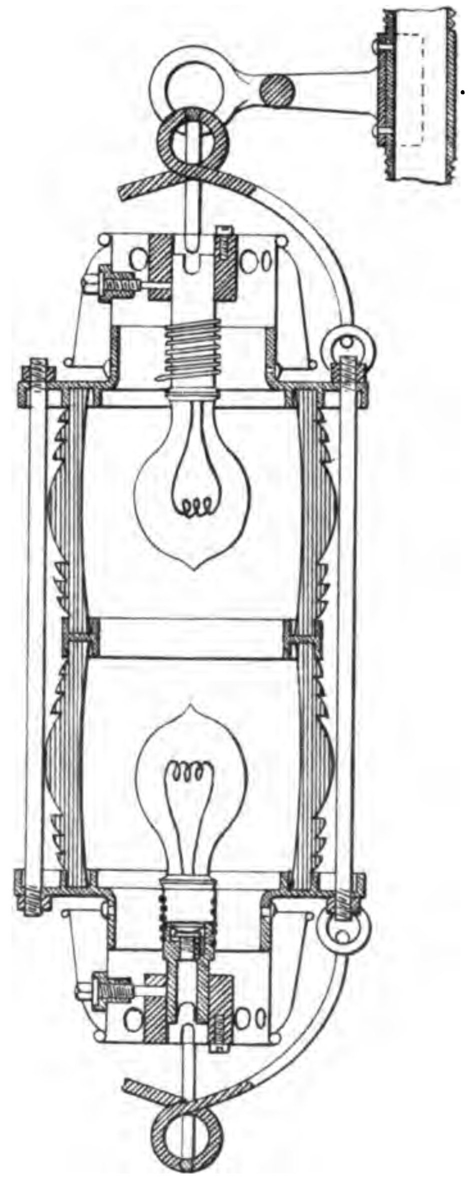
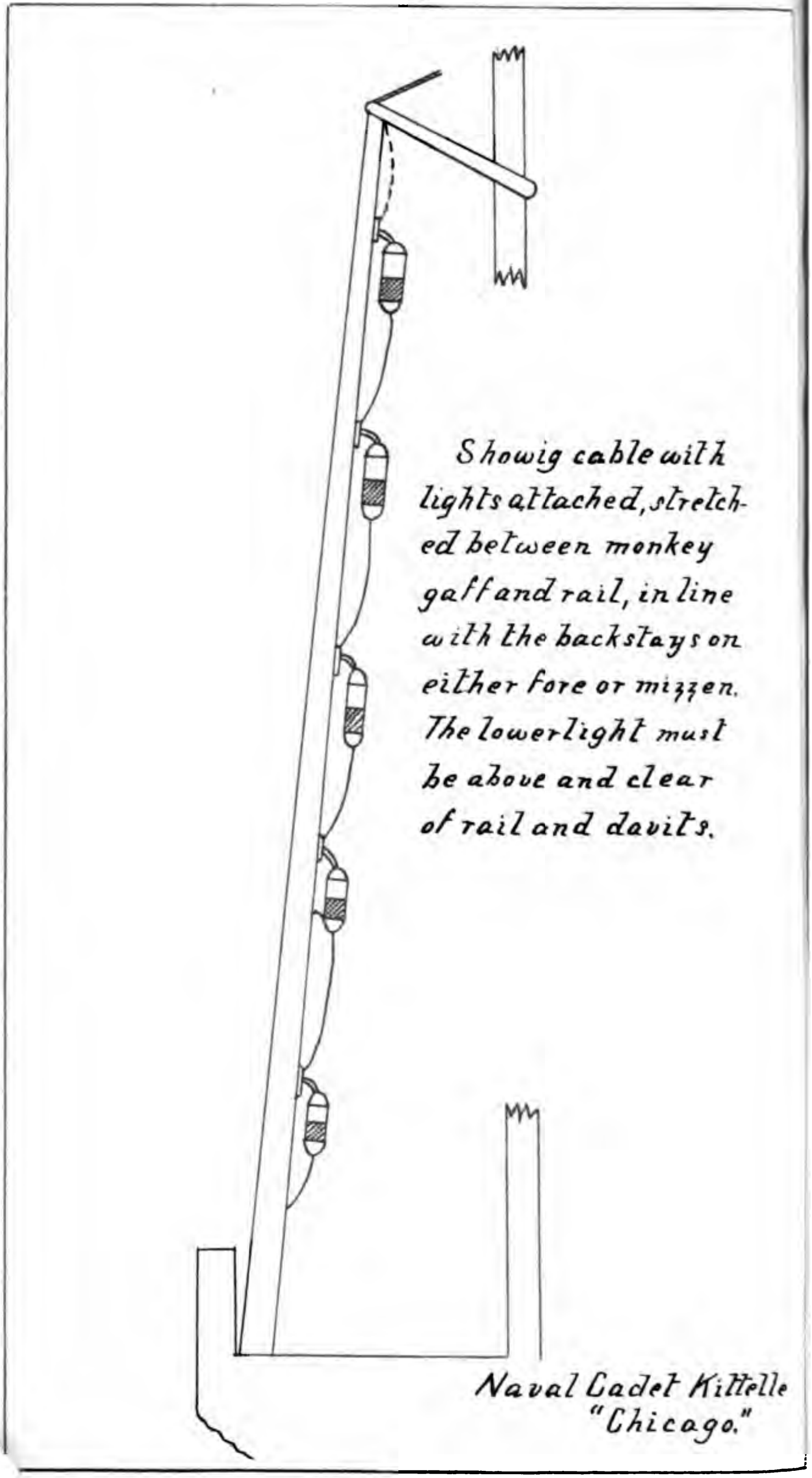


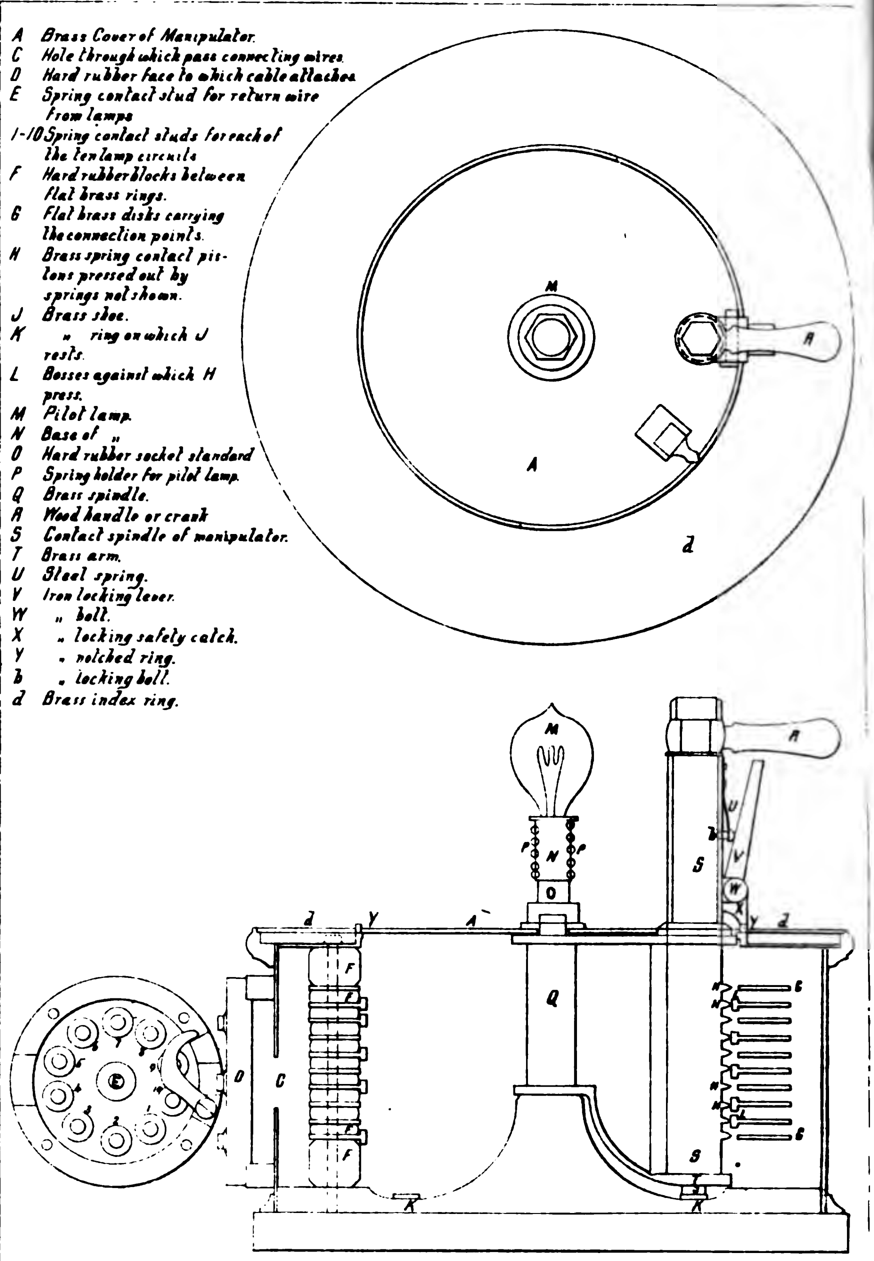
FIG. 21



Showig cable with lights attached, stretched between monkey gaff and rail, in line with the backstays on either fore or mizzen. The lower light must be above and clear of rail and davits.

Naval Cadet Kittelle
"Chicago."

FIG. 23



A	Brass Cover of Manipulator.
C	Hole through which pass connecting wires.
D	Hard rubber face to which cable attaches.
E	Spring contact stud for return wire from lamps
1-10	Spring contact studs for each of the ten lamp circuits
F	Hard rubber blocks between flat brass rings.
G	Flat brass disks carrying the connection points.
H	Brass spring contact pistons pressed out by springs not shown.
J	Brass shoe.
K	" ring on which J rests.
L	Bosses against which H press.
M	Pilot lamp.
N	Base of "
O	Hard rubber socket standard
P	Spring holder for pilot lamp.
Q	Brass spindle.
R	Wood handle or crank
S	Contact spindle of manipulator.
T	Brass arm.
U	Steel spring.
V	Iron locking lever.
W	" bolt.
X	" locking safety catch.
Y	" notched ring.
b	" locking bolt.
d	Brass index ring.

The spiral lamp sockets have a play of nearly 2 inches, which renders it possible to adjust any ordinary lamp in the focus of the lens lantern. The report of their behavior shows that the lamps and their connections have stood up to the present time 4 months' exposure to all weathers without injury and without giving the slightest difficulty. The diminution of relative brilliancy in the red lanterns is scarcely noticeable except at considerable distances.

Conductors.—The cable contains eleven insulated copper wires, of which one is used for a common return for the ten lamps, and which form altogether a single cable, establishing communication between the lamps and the manipulator.

The arrangement for suspending the lanterns is as follows (Fig. 21): A monkey gaff is placed as high up on the topgallant mast as it can be carried and the lanterns are suspended by a special backstay from the outer end, so as to avoid bringing the upper light too near the mast. Each lantern is supported by a short arm permanently secured to the cable. After the cable carrying the lanterns is triced up, it is seized to the backstay at each suspension arm. The conductors run direct from the keyboard to the lanterns, and are covered in together so as to make one cable until the lanterns are reached, where each one of the ten wires is left out and connected to its proper lamp, a branch from each lamp being spliced into the common return. Thus there are 4 wires leading into each lantern.

The lanterns being placed about 12 feet apart, the smallest vessel of the squadron will permit of all the lights being clear of obstructions and the space is ample to avoid blending and confusion at distances within the power of the lights.

Keyboard.—The keyboard (Fig. 23), which constitutes the most original part of the system, is inclosed in a box and is supposed to be watertight, but experience shows that it should not be unnecessarily exposed to the weather. The keyboard consists essentially of a circular plate, *d*, upon which are engraved in a circle all the combinations that can be made with the lanterns employed. The marking of the index plate is shown in Fig. 22. Each combination occupies a distinct sector; it is designated by white or red dots, reproducing exactly the order and proportions of the colors of the corresponding signal and it is marked with a letter, a number, a compass course, or a convenient phrase. The plate *d* (Fig. 23) covers a set of annular disks, G, in number equal to that of the incandescent lamps, and the disks are placed horizontally like the dial plate. The disks are insulated electrically from each other and each connected by a special wire to the corresponding lamp; they are not exactly circular, but present projections "L" in each sector. Inside the dial plate, on which are marked the sectors, is the manipulator, consisting of a brass cover, A, which revolves about a vertical axis, Q; this cover, A, carries a spindle, S, which revolves with it without touching the disks. In the body of the spindle are chambers with spring pistons, H, equal in number to the disks, and which make contact with the latter, but only in the sectors where the disks present projections (bosses). The cover A carrying the spindle is revolved until the pointer is exactly opposite the sector whose display is to be signaled. Fig. 23 shows the spindle S and crank R attached to its upper end in such position that the pistons make contact with such bosses as are presented.

The pin *b* fits into a hole in the spindle, but is held out by the spring U. Pressing in the lever V releases the catch, or lower toe, from the notched ring Y and permits the manipulator to turn in azimuth, but at the same time it presses in the pin *b*, thus preventing the handle R from being turned on until the lever V is again released and its lower toe X allowed to rest in one of the slots in the notched ring Y. Hence the lamps can not be lighted until the manipulator is clamped in proper position by lever V; nor can the manipulator be unclamped and revolved without first turning off the lights. The keyboard is located in such a part of the vessel as convenience may best dictate.

To dismount the manipulator. Remove the pilot lamp, disconnect the wires, and unscrew the lamp socket. Remove the central nut which holds down the central movable plate. Turn the manipulator until the pointer is at the vacant space between sectors 62 and 1. Then, grasping the handle, lift the manipulator carefully out, working it gently, if it meets obstructions, until it is clear.

The working of the apparatus is simple. The current coming from the source enters the keyboard by way of the axis Q, thence into the spindle of the manipulator.

As soon as the crank (the pointer being opposite the designated sector and the safety catch engaged) is turned through 90 degrees, contacts are established with the disks by means of the spring pistons, and the corresponding lamps are lighted, there being no break in the return circuit, the current returning from the lamps passing through, but insulated from the keyboard. Of the 62 combinations on the dial plate, four (59, 60, 61, 62) are used as keys. A code of signals is formed comprising as many chapters as there are combinations, the four keys indicating the changes of the titles of these chapters. We will have then 58 chapters each containing 58 signals; in other words, after making the key signals, we can, with but two displays, make 3,364 distinct signals, altogether 13,456 signals. Eighteen of the 62 combinations are used as indicative or introductory signals to determine the reading of the displays which follow or precede, also "danger," "position," and "execution," with four left vacant. The sectors of the remaining 40 numbers are divided into two concentric divisions, the inner of which is marked with the letters of the alphabet, also "tion," "ing," and the Arabic numerals; and the outer divisions with the 32 compass points, also "$\frac{1}{4}$ stbd," $\frac{1}{4}$ port, $\frac{1}{2}$ stbd, "yes," and "no."

The code to be used with this system would be divided into four parts, one under each key, and each part into 58 chapters, thus:

$$\text{Key I, Chapter I, would include signals} \ldots\ldots \left\{\begin{array}{l}1\text{–}1\\1\text{–}2\\1\text{–}3\\\ \text{to}\\1\text{–}68\end{array}\right.$$

$$\text{Key II, Chapter 37, would include signals} \ldots\ldots \left\{\begin{array}{l}37\text{–}1\\37\text{–}2\\\ \text{to}\\37\text{–}58\end{array}\right.$$

And the others in a similar manner.

The experience of our signal officers is that the chief use of such a code would be probably for a telegraphic dictionary, as it would hardly be the best form for a general signal book, which should be for both night and day use, and 62 elements would not be practicable for flag signaling. The Telegraphic Dictionary in its present form could have an additional column for night signals and rapidity of transmission be thereby greatly increased.

For a form of general signal book suitable to this system of night signaling and which offers a day code much superior to the one now in use, the form of the international code is recommended and the adoption of international flags, which have the required number for quick work and are much more distinguishable than ours.

The Ardois system has been given a thorough test in the squadron of evolution and the results may be summed up as follows: The system meets all reasonable expectations. It does not compete with Very's signals and lays no claim to value for long distances, but in its special field—that of squadron-signaling—it would appear to have no rival in certainty and security. The range may safely be given as 2 miles and in good weather 3 miles. Within the limits of a squadron in formation it is read in any weather without the aid of glasses. A very important feature of the system is the fact that each display signaled is answered by a repetition of that display. The importance of this in tactical signals can not be too strongly urged. When a signal is finished and the display "Action" is made, it is known positively that the signal has been correctly received. This certainty is not attained by any system of signaling, either night or day, when a simple answering light or pennant is shown. The principal disadvantage of the system is that the permanent installation of the lights causes them to be masked by masts, rigging, etc., on certain bearings.

This objection is felt more at anchor than under way and is much more noticeable in a ship like the *Chicago* or *Boston* than it would be in a mastless ship. The difficulty in squadron under way is not a serious one, as a ship can show her signals by a slight change of course. It is also diminished by the fact that, each answer being a repetition of the signal, a ship from which the flag-ship's lights are masked can take the signal from one of the receiving vessels. The keyboards are simple and strong. A few minor defects in workmanship were noticed, but these, both mechanical and electrical, can be easily remedied. The value of the signals to the squadron of evolution can be measured by the loss which would be felt if they were taken away. The squadron can be manœuvred by them as easily at night as in the daytime. On a dark rainy night off Pensacola, when torches would have been extinguished, and any Morse code signaling, slow and uncertain, the squadron was gotten under way and formed; distance, speed, and course were given with all the ease and rapidity which usually attend the best circumstances in daylight. Several emergency signals can be made, each requiring but a single display. Admiral Walker concludes his report on this system by saying that the signals are a great convenience and a great safeguard. They are always ready for use and their timely employment may avoid a collision or warn a vessel against going ashore.

For long-distance signaling at night Very's system is still invaluable. The experience of the squadron of evolution and other vessels has fully demonstrated this fact. In the English navy, the semaphore, which has long formed a part of their signal outfits, is used also at night, being illuminated by the aid of a reflector and a few incandescent lamps.

Should any vessels that are not already provided with lighting plants, require the Ardois system, a small hand dynamo would supply the necessary energy for the signal lamps, the latter being in this case of low voltage.

Of late years there has been a tendency to utilize the telephone as a part of the electrical outfit of ships. Recent experiments in the North Atlantic squadron have resulted in recommending it to replace the voice tubes now in use as a means of interior communication, and this being the case, its advantages over voice tubes are apparent. It has already been adopted for this purpose to some extent in the French navy; though, in the English navy, voice tubes are still used for all means of interior communication, in connection with electric call bells, as has been our custom.

The Société Générale des Téléphones in France have erected a considerable number of installations on board ship to enable communication to be maintained between the various parts with greater facility than by the use of speaking tubes. Among the more important ships fitted are the ironclads *Dévastation*, *Redoubtable*, *Admiral Duperré*, *Courbet*, *Admiral Baudin*, the cruiser *Cécille*, torpedo cruiser *Sfax*, and the Spanish ironclad *Pelayo*. In these, all the circuits radiate from the conning tower. Care has been taken to make every part as strong as possible and to avoid all chances of breakdown. To this end the conductors are made of copper ribbon and efficiently insulated. In those cases in which an officer or a man has two lines through which he can speak, each line is provided with its own apparatus complete for sending and receiving, and no attempt is made to make one apparatus serve for both lines. The telephone apparatus consists of "Berthon" microphone transmitters and "Ader" receivers. Experiments on board the *Dévastation* proved that with this apparatus a conversation was not interrupted between the conning tower and the central battery, even during the firing of the heavy guns. The "Berthon" microphone is so constructed that damp has no influence upon it. This is also the case with the "Ader" receiver, the coils of which are let into a bituminous block. On board the *Dévastation*, an apparatus has been used after having been immersed in a pailful of sea water. The cells employed are Léclanche Ager-Ager cells (dry). The call bells have different sounds, so as to distinguish them from one another.

As the telephone is useful for other purposes on board ship, for instance, establishing communication between ship and shore, ship and boat, service with naval brigade, diving apparatus, etc., it is destined in future to form a regular part of the electrical equipment of vessels. Some improvements in diving apparatus have been effected by M. Albert Marcelhacy, a French engineer. Instead of the heavy electric hand lamp hitherto used by divers, he affixes a light but powerful glow lamp on the top of the helmet, so that the diver's hands are both at all times free for work. These improvements have been adopted in the French navy.

The writer is not aware of any further experiments towards utilizing the search-light beam for long-distance signaling more recent than those mentioned in General Information Series, No. VII. Bell and alarm circuits, operated by primary batteries, are a part of the electrical equipment of our new vessels, for signaling from the water bottoms and coal-bunkers, for closing of water-tight doors, night quarters, etc. Much remains to be done, however, towards developing apparatus for communication. For instance, communication between vessels in a fog or at night without the display of lights; signal for closing water-tight doors, the present arrangement of shrieking whistle being unsatisfactory; an arrangement for showing instantly and continuously and in any desired part of the vessel the exact number of revolutions per minute being made by each engine at that instant, an arrangement of this sort being especially necessary in squadron tactics. The Department expects soon to install in the new vessels a satisfactory system of electrical engine-room and steering telegraphs, as well as revolution and helm indicators. An electric telegraph, for transmitting the range from the conning tower to the gun divisions, has been installed by the Navy Department during the past year on board the *Yorktown*. As our Navy is not yet provided with an automobile torpedo, no signal circuits are as yet necessary from the conning tower to the torpedo tubes.

MISCELLANEOUS APPLICATIONS.

Granville's electric log.—One of these logs, which are made by Elliott Brothers, has been installed on board the *Orontes*, and it is also in use in the Argentine navy. Although essentially an electric log it contains no battery; the log and the iron hull of the ship are the two electrodes and the sea water is the exciting liquid. It is of very simple construction and has only two moving parts—a revolving head and a small internal worm wheel. The head is connected with the worm-wheel gearing, and every sixth revolution of the former is communicated by means of a spring contact through the towline to an indicator placed on the ship. The indicator consists of a small metal circular box, with the necessary internal mechanism and external dials and pointers. The apparatus has shown itself to be an efficient means of accurately indicating, at any part of the ship where an indicator is located, the total distance run and the speed.

No electric welders have yet been introduced on board any men-of-war. The "Fiske Range Finder" has been installed in the *Chicago* and *Baltimore*, and is now being tested by foreign naval authorities.

In conclusion, the writer would call the attention of the naval service to the steadily increasing demand for electric motors on board ship, the many well-known advantages of which are causing them to be preferred to the numerous small steam-engines now in use; to the promising field for the storage battery; to the present demands for incandescent lighting, so conducive to health and comfort, and which is not only a saving in attendance, but, above all, allows us to work in otherwise inaccessible parts of the ship at night as well as by day; and lastly, but more important than all the others, to the development of the "search lights," which are not only necessities as weapons of defense and offense, but, as recently shown at Gibraltar at the sinking of the *Utopia*, are frequently instrumental in saving life.

NOTE.—In the preparation of the above article the resources of the library and current periodicals have been utilized; and the thanks of the writer are due to the Naval Inspector of Electric Lighting and the Chief Intelligence Officer for access to the records.

V.

THE NAVAL MANŒUVRES OF 1890.

By Lieut. CHARLES C. ROGERS, U. S. Navy.

In the preparation of this narrative, official reports have been utilized when available; but much of it is based upon press dispatches. In the main it is perhaps correct, but the uncertainty of the latter source should be remembered.

In the account of the English manœuvres reference has been made to a parliamentary return entitled "The Partial Mobilization of the Fleet and the Manœuvres of 1890," which lacks details or mention of results.

ENGLAND.

The principal object of the manœuvres was—

To ascertain under what conditions a hostile fleet could maintain itself on an important trade route and interrupt the traffic, always endeavoring to avoid a general engagement; also under what conditions a slightly superior British fleet could successfully manœuvre to bring the hostile force to action and compel it to return to port.

The subsidiary objects were—

To obtain information as to the most advantageous methods of employing a considerable body of scouting cruisers on both sides.

To ascertain the measures which a reserve fleet, chiefly composed of coast-defense vessels, whilst operating from a strategic point in the English Channel, should take to contribute to the support of the main fleet and to protect itself against torpedo-boat attack.

To ascertain what form the tactics of torpedo-boats operating from a distant base should assume.

GENERAL IDEA.

The following General Idea was adopted:

Hostilities being imminent, the cruisers on both sides may put to sea to watch the movements of the opposite side and report proceedings.

Immediately on the declaration of war the Hostile fleet puts to sea, and takes up the position which its commander may consider most suitable on the trade route which enters the English Channel from the westward. The limits of this route are colored on the chart.

Twenty-four hours after the enemy's departure from port the British fleet proceeds to look for him, in order to engage him or compel him to return into harbor.

So long as the Hostile fleet maintains its position on the trade route all the sea-borne trade of the other side that continues to follow that route is at its mercy; consequently simulated attacks on commerce will, for the purpose of the manœuvres, be unnecessary; the employment of cruisers will therefore be devoted to scouting and dispatch services.

The Hostile fleet may resort to Berehaven and the Shannon, which will be assumed to be isolated from the rest of Ireland, and to which no intelligence will be supplied from the other parts of the United Kingdom.

The British fleet may resort to any port in the United Kingdom not lying between Carnsore Point and Cape Clear, or between the latter and Achill Head.

Berehaven and the Shannon are to be considered secure against naval attack.

Full value is to be given to the existing defenses at all ports to which the British forces may resort.

The ships, colliers, etc., in all the above ports will be open to torpedo-boat attack unless protected by defenses especially arranged.

When hostilities become imminent the Reserve fleet will move to Portland, and will there secure itself against torpedo-boat attack, at the same time keeping constantly in readiness to put to sea at the shortest notice.

A division of hostile torpedo-boats, with an escorting cruiser, will assemble at Alderney and use that as a base of operations against the Reserve fleet, or any ships of the British fleet that may navigate the English Channel.

Portland is to be considered secure against attack. Full value is to be given to the existing defenses at Alderney.

The ships, colliers, etc., in them will be open to torpedo-boat attack.

As the naval forces on either side are assumed to be nearly equal, attacks on fortified ports are not admissible, and are not to be made.

As the attacks on unfortified coast towns would not affect the general result of a war under the assumed conditions, such attacks are not admissible and are not to be made.

INTRODUCTORY CRUISES.

The British fleet will assemble at Portland.

The Hostile fleet will assemble at Torbay.

The Reserve fleet will assemble in the Downs.

Mobilized and newly-commissioned ships are to proceed direct to those anchorages without calling at Spithead.

When in all respects ready the British and Hostile fleets are to go to sea for a period which may be extended to 10 days for target practice and exercise in fleet evolutions. The Reserve fleet will put to sea for target practice and exercise in fleet evolutions, anchoring and weighing as far as possible daily, and will finally assemble at Portland not later than the tenth day.

Each First Reserve ship is to carry out the full periodical firing at a target as due.

Each ship that has been mobilized for manœuvres is to fire at a target as directed by the regulations specially dealing with mobilized ships.

The target practice is to be spread over at least two days.

All other ships are to complete the quarterly target practice due in accordance with the regulations.

OPERATIONS.

At the expiration of the introductory cruises the British fleet is to put into Plymouth, the Hostile fleet into Berehaven, and the Reserve fleet into Portland. The torpedo boats not already there will proceed to their assigned bases. The cruisers are to be sent in so as to reach the above ports in time to be completed with coal before the fleets arrive. All ships and torpedo boats on arrival are to complete with coal.

On the arrival of the main fleets in port the following message will be telegraphed to each:

War imminent. Cruisers may observe probable hostile movements.

On receipt of this message the Admiral on each side may use his discretion as to the time at which his cruisers should start, the number that should go, and the instructions which should be given to their captains.

As soon as the battle ships are ready it is reported by telegram to the Admiralty. A telegram—

Hostilities are to begin at ——— on the ———, and end at ——— on the ———.[*]

will be sent, when the Hostile fleet will put to sea to carry out its part of the scheme of operations.

Twenty-four hours later the British fleet will be ordered by telegram to look for and drive in the enemy.

At the termination of the manœuvres, the Hostile fleet will repair to Torbay and the British fleet to Portland, in order that all mobilized ships and torpedo boats belonging to the three fleets may be inspected prior to dispersal for paying off.

NOTE.—During the manœuvres no foreign coast is to be approached within 5 miles.

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[*] The second date will be 10 days later than the first.

The 1890 manœuvre trade route will be comprised within the following limits:

(1) On the south coast of England:

Between that coast and a line drawn from a point 10 miles (tru south of the Lizard to a point 10 miles (true) south of the Start, the to a point 10 miles (true) south of St. Catherine's, thence to a point 1 miles (true) south of Beachy Head, thence to a point 10 miles (tr south of Dover.

(2) On the southwest coast of England:

Between that coast and a line drawn from a point 10 miles (true) w of the Scilly Islands to Carnsore Point in Ireland.

(3) In the Atlantic Ocean between lines:*

(*a*) From the point 10 miles (true) west of the Scilly Islands to point 110 miles (true) west of Ushant.

(*b*) From the last mentioned point through another point in 41° nor latitude and 20° west longitude.

(*c*) And from the point 10 miles (true) south of the Lizard throu another point in 37° north latitude and 15° 30′ west longitude.

RULES FOR THE GUIDANCE OF UMPIRES.

There will be a Chief Umpire and two Umpires who will assembl to investigate claims in concert and give decisions thereupon.

(1) The decisions of the umpires are to be final.

(2) Umpires should not make known their reasons for arriving at decision.

(3) No reference is to be made to the Admiralty before arriving at decision.

(4) The decisions of umpires are to be published to the squadrons an communicated to the Admiralty as soon as possible after they hav been arrived at.

(5) Any obvious departure from what would be possible in war—though not specifically provided for in the rules—is to be dealt wi by the umpires on its merits.

NOTE.—Copies of these rules are to be issued for the information o officers engaged in the manœuvres.

RULES AS TO RELATIVE STRENGTH OF OPPOSING FORCES.

(6) Ships, vessels, etc., in the same group, for the purposes of the manœuvres, to be considered equal to one another.

(7) The groups are the following:

Group (*a*). Battle ships.

Group (*b*). Coast-defense armor clads and first-class cruisers.

Group (*c*). Second-class cruisers.

Group (*d*). Third-class cruisers.

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* These lines are not limited in length towards the south and west.

Group (*e*). Sloops, gun vessels, and first-class gunboats.

Group (*f*). Other gunboats.

(8) An individual in any group of ships or vessels is to be considered superior to an individual in any other group placed lower in the list.

(9) An individual in any group is to be considered as of two-thirds he strength of an individual in the group immediately preceding; and his proportion is to be allowed for in computing the relative strength f members of groups farther apart.

(10) Members of groups (*d*), (*e*), and (*f*) are not to be considered of ay account against members of group (*a*).

(11) Members of groups (*e*) and (*f*) are not to be considered of any ccount against members of groups (*a*) and (*b*).

(12) Members of group (*f*) are not to be considered of any account gainst members of groups (*a*), (*b*), and (*c*).

(13) Torpedo boats are to be divided in two groups, viz:

Group (*g*). Torpedo boats of more than 100 feet in length.

Group (*h*). Other torpedo boats.

(14) Torpedo boat against torpedo boat; an individual in group (*h*) s to be considered as of two-thirds the strength of an individual in group (*g*).

(15) Squadrons are to be considered equal, unless one is stronger than he other by at least one-sixth.

RULES FOR ENGAGING.

(16) Fire is not to be opened or continued at a greater distance than 4,000 yards.

(17) No ship is to approach within 5 cables of an enemy's ship.

(18) During an engagement, each ship actually engaged and within he regulated distance is to fire a gun at 5-minute intervals.

(19) In order that an engagement between squadrons may be decisive, he following conditions must be fulfilled:

(*a*) The engagement must last 2 hours.

(*b*) One force must be superior to the other.

(*c*) The ships of the superior force must be sufficiently in hand to ford one another mutual support.

(*d*) The distance of 4,000 yards between the nearest ships of both des must never be exceeded.

(20) After a decisive engagement, the beaten force is to return to one f its fortified ports, where it is to remain 48 hours before again putting o sea.

(21) After an indecisive engagement of not less than 2 hours' duration, both sides are to return to one of their own ports, from which they e not to put to sea again till after the expiration of 24 hours from rival.

(22) Any vessel which is exposed for half an hour to an obviously erw 'ming fire from ships of the proper groups within the regulated

distance is to return to port, and not again put to sea till after the expiration of 48 hours from arrival.

(23) If a squadron or single ship at anchor in a port unfortified, and not defended by unloaded mines actually placed in position, permits an enemy, of even slightly inferior force, to approach within 2,000 yards by day or night, the squadron or single vessel so anchored is to be considered to have been disabled and incapable of taking further part in the manœuvres for 48 hours.

(24) If a squadron or single vessel approaching a hostile force at anchor for the purpose of ramming the latter is held by the umpire to have been disabled by mines, such squadron or single vessel is to return to port, and take no further part in the manœuvres for 48 hours after arrival.

(25) Ships, vessels, etc., put out of action are to hoist in the most conspicuous position an ensign as a weft.

(26) In order that an action between single ships may be decisive the following conditions must be fulfilled:

(*a*) The action must last one hour.

(*b*) One side must be superior to the other.

(*c*) The distance of 4,000 yards between the engaging ships must never be exceeded.

(27) After a decisive engagement the unsuccessful ship must go into one of the ports of her own side for 24 hours.

(28) After an indecisive action between single ships, lasting one hour, each side is to go into one of its ports for 24 hours.

(29) All engagements are to be considered as beginning with the firing of the first gun within the regulated range.

(30) Colliers passing to and fro between the port of loading and the fortified ports specified in the scheme of operations will not be liable to capture. Under all other circumstances, if insufficiently escorted, they will be liable to capture.

RULES FOR TORPEDO BOATS AND TORPEDO BOAT ACTIONS.

(31) Each torpedo boat is to carry two torpedoes fitted with safety heads.

(32) No torpedo boat is to fire more than one torpedo at a time.

(33) No torpedo is to be fired at a greater distance than 500 yards from the craft attacked.

(34) After a torpedo boat has fired a torpedo she is to pick it up, and the boat and crew are to take no further part in the operations for hours.

(35) A torpedo boat which has been under the continuous fire, whether of a friend or an enemy, for 2 minutes 30 seconds, within 2,000 yards, is to be put out of action, and neither she nor her crew are to take any further part in the operations for 48 hours.

(36) A vessel actually struck by a torpedo is to be considered temporarily disabled, and is to take no further part in the operations for 48 hours.

(37) If a superior torpedo boat or force of torpedo boats succeeds in maintaining for 15 minutes a position within 400 yards of a hostile torpedo boat or force of torpedo boats, such hostile boat or force is to take no further part in the operations for 48 hours.

(38) Ships attacked by torpedo boats are to fire blank from quick-firing machine guns and small arms; but are not to use any heavier guns.

(39) Any craft temporarily disabled by torpedo-boat attack is to hoist position lights at night during the time that she is precluded from taking part in the operations.

(40) During the time that torpedo boats are precluded from taking part in the operations they are to keep their bow and steaming lights alight and showing at night.

MOBILIZATION.

The order for partial mobilization was issued on the 21st of July. On the following day twenty-four ships of various classes and twenty-four torpedo boats were put in commission. Nine First Reserve and three flagships—all the twelve being armor-clads—had their crews completed. On the 26th, 4 days after commissioning, thirty-three of the above thirty-six ships, and all the torpedo boats, had reached the points of assembly. By the 27th of July the whole had assembled, and, with the Channel squadron, the training squadron, and a few other vessels previously in commission, formed a total of fifty-six ships of different classes and twenty-four torpedo boats. The united crews comprised 18,860 officers and men, of whom 7,442 belonged to the ships specially commissioned, and 1,499 were absorbed in completing the complements of the First Reserve ships.

As the number of ships in commission previous to mobilization was larger in 1890 than in 1889, less difficulty was experienced this year in rapidly manning the ships in the Medway. But as it was, 866 men had to be transferred from Portsmouth and Devonport to Chatham. The increased capacity of Chatham dockyard for equipping ships, owing to its modern extension, has outstripped the ordinarily available resources of the Sheerness command as regards personnel. This constitutes an impediment to efficient mobilization which will have to be encountered during the continuance of present conditions, under which the men, especially those with trained ratings, are principally to be found within the limits of two commands, whilst the ships to be mobilized are in three. The aggregate number of engine-room ratings of the whole fleet when assembled was 3,827, and there were no deficiencies; indeed, a certain number of firemen, second-class, were distributed as supernumeraries amongst the ships to gain sea experience during the manœuvres. The deficiency reported in signal ratings, viz, 11, was more tha covered by an available surplus of 19 at the ports.

The ships composing the forces on both sides are as follows:

I. THE BRITISH.

A FLEET.

[Headquarters, Portland.]

Vice-Admiral Sir GEORGE TRYON, K. C. B., in command; Rear-Admiral R. E. TRACEY, second i command.

Ships.	Length.	Guns.	Tons.	H. P.	Sea speed.	Complement.
BATTLE SHIPS:	*Ft. In.*				*Knots.*	
Northumberland (flag)	....	29	10,780	6,560	11.5	[illegible]
Anson (flag of second in command)	....	10	10,600	11,500	16.8	[illegible]
Rodney	....	10	10,300	11,500	15	[illegible]
Inflexible	....	12	11,880	8,010	11.5	[illegible]
Invincible	....	16	6,010	4,839	11.6	[illegible]
Triumph	....	16	6,040	3,659	12.5	[illegible]
Black Prince	....	28	9,210	5,770	10.8	[illegible]
Hero	....	6	6,200	6,000	13.5	[illegible]
ARMORED COAST-DEFENSE VESSEL:						
Hotspur	....	4	4,010	3,060	10.5	[illegible]
ARMORED CRUISERS:						
Narcissus	....	12	5,600	8,500	18.5	[illegible]
Galatea	....	12	5,600	8,500	18.5	[illegible]
Shannon	....	9	5,390	3,370	10.5	[illegible]
PROTECTED CRUISERS:						
Thames	....	12	4,050	5,700	15.8	[illegible]
Mersey	....	12	4,050	6,000	16	[illegible]
Medusa	....	6	2,800	9,000	20	[illegible]
Mohawk	....	6	1,770	3,500	15.3	[illegible]
Raccoon	....	6	1,770	4,500	15.6	[illegible]
PARTIALLY PROTECTED CRUISER:						
Basilisk	....	8	1,170	2,107	13.9	[illegible]
UNPROTECTED CRUISERS:						
Inconstant	....	16	5,780	7,360	14.3	[illegible]
Iris	....	13	3,730	7,330	16	[illegible]
TORPEDO VESSELS:						
Speedwell	....	2	735	3,584	19.4	[illegible]
Spider	....	1	525	3,000	17.3	[illegible]

RESERVE OR B SQUADRON.

[Headquarters, the Downs.]

Commodore POWLETT in command.

Ships.	Length.	Guns.	Tons.	H. P.	Sea speed.	Complement.
ARMORED COAST-DEFENSE VESSELS:	*Ft. in.*				*Knots.*	
Cyclops		4	3, 560	1, 660	11	192
Gorgon		4	3, 560	1, 670	11. 1	192
Hecate		4	3, 560	1, 670	10. 9	192
COAST-DEFENSE VESSELS:						
Glatton		2	4, 910	2, 870	12. 1	191
Hydra		4	3, 560	1, 470	11. 2	192
ARMORED CRUISER:						
Belleisle		4	4, 870	3, 200	12. 2	282
UNPROTECTED CRUISER:						
Active (*flag*)		12	3, 080	4, 130	15. 1	357
TORPEDO DEPOT VESSEL:						
Hecla		6	6, 400	2, 260	11. 7	273
TORPEDO VESSELS:						
Grasshopper		1	525	3, 000	17. 2	63
Rattlesnake		1	550	2, 700	17. 3	63
TORPEDO BOATS:						
No. 65	125 0			640	20	16
No. 67	125 0			660	20	16
No. 68	125 0			650	20	16
No. 72	125 4			670	20	16
No. 73	125 0			960	22	16
No. 74	125 0			700	20	16
No. 78	125 1			720	18. 5	16
No. 79	128 8			990	20	16
No. 80	135 0			1, 540	21. 5	21
No. 83	130 0			1, 130	22. 6	19
No. 84	130 0			1, 130	22. 6	19
No. 85	130 0			1, 130	22. 6	19

FOR SPECIAL SERVICE.

PROTECTED CRUISER:						
Calypso		16	2, 770	3, 720	11. 9	318

II. The Enemy.

C FLEET.

[Headquarters, Torbay.]

Vice-Admiral Sir Michael Culme-Seymour, Bart., in command; Rear-Admiral F. C. B. Robinson second in command.

Ships.	Length.	Guns.	Tons.	H. P.	Sea speed.	Complement
Battle ships:	*Ft. in.*				*Knots.*	
Camperdown (*flag*)	....	10	10,600	11,500	16.8	530
Minotaur (flag of second in command)	....	21	10,690	4,800	14	[illegible]
Howe	....	10	10,300	11,500	16.8	515
Conqueror	....	6	6,200	6,000	15.5	335
Iron Duke	....	14	6,010	3,520	10.5	455
Audacious	....	18	6,010	4,830	13.5	402
Neptune	....	6	9,310	8,000	12.3	545
Ajax	....	6	8,660	6,440	11	403
Armored cruisers:						
Aurora	....	12	5,600	8,500	18.5	[illegible]
Immortalité	....	12	5,600	8,500	18.5	[illegible]
Northampton	....	12	7,630	6,070	11.2	568
Protected cruisers:						
Curlew	....	4	950	1,500	12	106
Arethusa	....	10	4,300	5,500	15	297
Forth	....	12	4,050	5,700	18	225
Medea	....	6	2,800	9,000	20	[illegible]
Serpent	....	6	1,770	4,500	15.6	176
Tartar	....	6	1,770	3,500	17.3	[illegible]
Partially protected cruiser:						
Barrosa	....	6	1,580	3,110	16.9	134
Torpedo vessel:						
Sandfly	....	1	525	3,000	17.3	63
Armed tug:						
Traveller	....	2	700	1,210	12.1	53
Torpedo boats:						
No. 45	125 0	......	....	690	18.5	16
No. 51	125 0	......	....	680	18.5	16
No. 52	125 0	......	....	720	18.5	16
No. 54	125 0	......	....	720	18.5	16
No. 55	125 0	......	....	660	18.5	16
No. 57	125 0	......	....	740	18.5	16
No. 58	125 0	......	....	720	18.5	16
No. 59	125 0	......	....	750	18.5	16
No. 81	150 0	......	....	1,830	16	25
No. 82	130 0	......	....	1,180	22.6	19
No. 86	130 0	......	....	1,180	22.6	19
No. 87	130 0	......	....	1,130	23	19

FOR SPECIAL SERVICE.

Unprotected cruiser:						
Ruby	....	12	2,120	1,830	12.3	[illegible]

UMPIRES.

The umpires, who were directed to assemble in London, were Admiral Sir William M. Dowell, K. C. B., Vice-Admiral Sir Frederick W. Richards, K. C.B., and Rear-Admiral R. O'B. Fitz Roy, C. B.

COALING.

Steam colliers wers assigned to each of the fleets, and arrangements devised to represent the actual conditions of war as far as possible in peace manœuvres. No special arrangements were made for testing the coaling of ships at sea.

The eight colliers attached to the British fleet carried about 8,000 tons of coal.

PRELIMINARY OPERATIONS.

The main British fleet assembled at Portland, the Reserve squadron in the Downs, and the Hostile fleet in Torbay. The ships then put to sea for target practice and exercise in fleet evolutions for a period of 10 days. At the expiration of these introductory cruises the A fleet was to go to Plymouth, the Hostile or C fleet to Berehaven, and the Reserve or B squadron to Portland. The introductory cruise of the B squadron finished on the 5th August. On the 3d, eight of the cruisers of the A fleet proceeded to Plymouth to complete with coal before the arrival of the main fleet, and were followed by the *Galatea* and *Narcissus* on the 4th. On the morning of the 3d the cruiser division of the C fleet, in charge of Rear-Admiral Robinson, in the battle ship *Minotaur*, were sent into Berehaven. On the 5th, Vice-Admiral Sir Michael Seymour finally anchored at Berehaven* with the body of his fleet. Vice-Admiral Sir George Tryon arrived in Plymouth Sound with his battle ships on the 7th.

The main fleets having reached their base ports, the following message was telegraphed from the Admiralty: "War imminent. Cruisers may observe probable hostile movements." At 9 p. m. Commodore Powlett sent the *Rattlesnake* of the B squadron from Portland to reconnoitre Alderney and the adjacent islands, with a view of counting the enemy's cruisers and torpedo boats that might be at anchor in that neighborhood. Commander H. D. Barry, of H. M. S. *Curlew*, the hostile senior officer at Alderney, considering that the *Rattlesnake* was approaching nearer than was befitting a state of imminent belligerency, fired on her and claimed to have sunk her; but the claim was disallowed. The scouting operations of the A fleet began at 11 p. m. on the 7th August by the dispatch of a squadron of three cruisers to Pembroke.

On the 8th the battle ships on both sides were reported ready, when this telegram was sent from the Admiralty: "Hostilities are to begin at 5 p. m. on the 8th August, and will end at 5 p. m. on the 18th August."

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* The C fleet had anchored there also on the 4th, but had got under way again.

POSITIONS OF THE OPPOSING FORCES AT THE OUTBREAK OF WAR.

At the moment of beginning hostilities, the position of the respective forces was, stated generally, as follows: Three of the A cruisers—the *Mersey*, *Thames*, and *Medusa*—had been despatched to Pembroke; the rest of A fleet was lying in Plymouth Sound. The B squadron was at Portland, where it had taken measures to protect itself against torpedo boats. A detachment of the C fleet, consisting of the *Curlew*, *Traveller*, *Sandfly*, and three torpedo boats, was at Alderney. On the previous afternoon, the remaining nine torpedo boats of this fleet had been sent to Guernsey with orders to cruise or anchor as desirable off the southwest corner of the island. The rest of C fleet was at Berehaven.

MAIN OPERATIONS.

Sir Michael Seymour left Berehaven with his fleet at 5 p. m. of the 8th August.

The *Calypso* was used as a dispatch vessel for A. fleet during the manœuvres.

On the morning of the 9th the *Mersey*, *Thames*, and *Medusa* left Pembroke and proceeded on scouting service along the trade route.

The Admiral of A fleet received orders to look for and drive in the enemy, one day after the latter had left his port. Before the time arrived to proceed on the service, Sir George Tryon dispatched the *Iris*, *Narcissus*, and *Galatea* to a position on the west side of the trade route, as a squadron of scouts; and at 10 a. m. on the 9th, the *Mohawk* and *Raccoon* left on similar service for their special cruising grounds. Thus, before the arrival of the hour at which he was permitted to put to sea with his heavier ships, Vice-Admiral Tryon had thrown out three separate divisions of scouts along the trade route, and the *Speedwell* and *Spider* had been sent to Scilly to reconnoitre and report on its availability and value as a base.

TORPEDO-BOAT ATTACK ON A FLEET.

The senior officer of the enemy's detachment at Alderney had arranged to attack the A fleet at Plymouth during the night immediately following the beginning of hostilities. He accordingly planned two separate attacks; the first to be by three fast torpedo boats under Lieutenant Wells, the second—after what was to be an interval of 2 hours—by six boats under Lieutenant Sturdee. He also proposed to make a diversion by sending two torpedo boats against the B squadron at Portland, but with orders not to press the attack home, simply to cause an alarm. Commander Barry, speaking of the attack arranged against the ships in Plymouth Sound, reports that his "idea of a second attack was to let them cool down, and when they thought it was all over, give them another."

According to the report of the assailants, Lieutenant Wells, with thre boats, entered the sound through the eastern entrance to make the fir t attack. The ships were lying in three lines parallel to the breakwater, the four in line nearest that structure being the *Northumberland*, the *Rodney*, the *Anson*, and the *Black Prince*. The distance between the ships was 2 cables. It was round the eastern corner of this, shortly after 2 a. m., that the first attack was made. It was claimed that No. 87 torpedoed the *Invincible* and No. 86 the *Black Prince*. After rounding the breakwater and approaching within 150 yards of the *Black Prince*, No. 82 discharged a torpedo at that vessel. The air-chamber of the Whitehead seems to have sprung a leak, and so little speed was given to the weapon that it had only sufficient impetus to go near the ship. Immediately after firing, the order "hard a-starboard" was given, but the steering gear had broken down and the helm would not work. The engines were reversed, but not in time to prevent a collision, whereby 6 feet of the bow of No. 82 was bent to one side at an angle of fully 30 degrees.

Just before daybreak Lieutenant Sturdee made the second attack with six boats. They skirted round Cawsand Bay and supposed that they were not seen, as the leading boat was hidden by a large steamer going out. It was claimed for No. 81 that 1 minute after the alarm was given she torpedoed the *Northumberland*, and that she was not fired upon until after she had placed her bow lights in sign of having completed her work. No. 57 fired at the *Invincible*, but her torpedo did not run. No. 59 fired at the *Northumberland*, but missed her. No. 51 claimed to have torpedoed the *Inconstant*, but was herself struck by a friend's torpedo. No. 58 reported getting close to the *Inconstant* without being seen, and that she torpedoed that ship after only one gun had been fired at her. No. 55 had to ease her engines on account of hot bearings, and made an independent attack through the eastern entrance. When off the end of the breakwater she was discovered by a guard boat. Guns were fired and electric lights turned in every direction, according to her crew, but that of the boat. She claimed to have hit the already torpedoed *Invincible*.

A correspondent on board the *Northumberland* states that owing to the smoke of the guns of the fleet and the defective handling of the electric lights the torpedo boats might have done in actual war incalculable damage. As it was, each ship flashed her search light to a great extent in the eyes of the watchers on board other vessels.

As the British fleet did not receive permission to commence its navigation of the Channel until 5 p. m of the 9th, the Admiral apparently thought there was no ground for an attack by torpedo boats, for he made a general signal to the fleet: "Although I consider my hands are tied as yet, we are at no great distance from torpedo boats; therefore, keep a good lookout and have guns ready."

According to the reports of the ships the aspect of affairs was very different. All the boats that entered the sound by either entrance were believed to have been for several minutes in excess of the time allowed by rule under fire before they delivered their torpedoes. The boats at the east entrance were seen with the naked eye without difficulty. The night was clear, the moon high, and stars out. On such a night the electric light could not be usefully employed for protection, and it was not employed save for the purpose of puzzling the assailants. The fire of the ships united to protect and cover any and every ship that could be attacked by torpedo boat. The *Black Prince*, claimed as torpedoed, reported that no torpedo had struck her. The *Anson*, which had not been claimed by the attack, had a curious experience. A torpedo struck her picket boat, glanced off the boat, then glanced off the ship and ran to the breakwater. The *Invincible* considered that, when first attacked, she had kept the torpedo boat the regulated time under fire; and that in the second attack she was not hit by a torpedo at all. It was not disputed that the *Northumberland* had been struck abaft the mizzen rigging; but the *Rodney* reported that she had been firing for some minutes on a boat which was distinctly seen to discharge a torpedo at the *Northumberland*. The *Inflexible* reported that the torpedo-boat which first attacked the *Inconstant* was one of two which the *Inflexible* had brought under her fire for 4 minutes. According to the report of the *Inconstant* the boat, the second which attacked her and which torpedoed her, had been under her own fire and that of both the *Northumberland* and *Inflexible* for several minutes.

With regard to the affair, the umpires announced that the evidence contained in the reports from both sides was irreconcilable, and that it was impossible to come to any definite decision on the claims submitted to them.

A FLEET.

Twenty-four hours after the declaration of war the main fleet left Plymouth, and on the next morning arrived at the rendezvous, directly south of the Scilly Islands. On leaving the *Anson*, *Rodney*, and *Hearty* were sent ahead, with orders to support the cruisers previously dispatched along the trade route. During the 10th and 11th the fleet lay off and on within sight of the Scillies, and was joined by the *Mohawk*, *Raccoon*, *Mersey*, *Thames*, and *Medusa*, and by Rear-Admiral Tracey's division. Having thus accomplished the first step in the manœuvres, the main A fleet was off Scilly with three powerful fast cruisers—*Iris*, *Narcissus*, and *Galatea*—reconnoitring 100 miles to the southwest.

On the morning of the 12th the *Northumberland*, *Invincible*, *Shannon*, *Triumph*, and *Black Prince* anchored in Crow Sound, the remaining vessels cruising outside as before. As soon as the former ships had anchored, colliers steamed alongside and coaling began. In the beginning Admiral Tryon had directed several of his colliers to go to Falmouth, where he had coaled during the manœuvres of 1889; he wished the enemy to suppose that he would again use it as a coaling port. In reality he shifted his base from Plymouth to Scilly and not to Falmouth. When he supposed that the arrival of the colliers at Falmouth had become known he transferred as many as were needed to Scilly. Meanwhile the *Hotspur* was ordered to anchor in St. Mary's Road to act as guard ship and to protect the colliers. This change of base to Scilly while ostensibly establishing it at Falmouth virtually secured the colliers from molestation; for the operations of the enemy's torpedo boats from Alderny against the colliers left at Falmouth were very active. On the night of the 10th Nos. 86 and 87 put into Falmouth and attacked two colliers there as well as the *Hearty* and *Speedwell*; which had been directed to protect the former. The night was foggy and their approach was not observed till they were well in. It is claimed that they were driven off by the cruisers. On the night of the 11th No. 87 proceeded to Penzance, but finding none of the British ships returned to Falmouth, where she claimed to have captured three colliers in broad daylight on the 12th. Later she proceeded to Scilly. On the morning of the 13th, while making a reconnoisance of the British fleet, she was recognized and fired on. Her steering gear carried away, in 6 minutes temporary repairs were made, and although pursued by the *Spider* and the *Iris*, she escaped. On arrival at Plymouth she surrendered to get the steering gear repaired. The claim of No. 87 to have captured five colliers was disallowed by the umpires; on the other hand, the claim of the *Speedwell* and *Hearty* to have put Nos. 86 and 87 out of action was also disallowed. The captain of the *Hearty* reported that he had kept these torpedo boats under fire for 9 minutes, or more than three times the regulated period. The commander of the torpedo boats held that this firing was ineffective.

During these operations Vice-Admiral Tryon sent the *Mersey*, *Thames*, and *Medusa*, and other cruisers singly, to patrol the trade route where it was narrowest and most exposed to depredation. While this service was being performed he kept the main fleet off the Scilly signal station, with which he was able to communicate; but the only fact that was established by these 5 days of operations about the enemy was that he had not thrust himself in behind the British fleet.

On the morning of the 14th the main fleet spread itself across the trade route immediately to the south of the Scillies, and started at increased speed in a southwesterly direction. The most westerly of the line abreast was the *Shannon*, and at intervals of 3 miles were the *Black Prince*, *Triumph*, *Northumberland*, *Invincible*, *Inflexible*, *Hero*, *Anson*, and *Rodney*. Thus a breadth of 24 miles was covered by the advancing battle ships. The cruisers were abreast of the line of battle ships. The latter were ordered to maintain a distance of 3 miles apart, but the cruisers were directed to open out gradually on the flanks, so as to fill up the remaining breadth of the ever-widening trade route. Sir George Tryon expected to find the enemy on the side of the trade route nearest to Ireland, and in that direction, therefore, he disposed his main strength. The cruise southward continued until the night of the 15th, when latitude 46° 30′ north was reached. Having found no trace of the enemy, the fleet went about and returned to the Scillies, where it arrived on the morning of the 17th. It is stated that during this cruise the disposition of the fleet was such that, while it covered the space that had to be searched, the ships could have been assembled and formed in order of battle before an enemy sighted by the scouts could have approached within engaging distance.

During the 17th the fleet again stood to the southwestward of the Scillies, apparently to bar the mouth of the channel should the enemy attempt a dash at the last moments of the campaign. The *Black Prince* broke down almost immediately, and for 24 hours afterwards had to be taken in tow. The *Basilisk* also broke down and was taken charge of by the *Shannon;* and on the 18th, though the fleet was steaming at less than 9 knots, the *Triumph* signaled that she was unable to keep up, and was obliged to drop behind.

When hostilities ceased on the 18th the main body of A fleet was about 50 miles southwest of the Scillies. The next morning it steamed into Portland Roads.

RESERVE OR B SQUADRON.

The ships at Portland were disguised as much as possible. Torpedo nets were lowered, mines laid out, and all measures for protection of the squadron were completed.

It has been stated that the movement by two of the Alderney torpedo boats against the B squadron was a feigned and not a real attack; Commodore Powlett reported that hostile torpedo boats were observed by the *Grasshopper* and No. 74, which gave the alarm at 1:25 a. m. and 2 a. m. on the 9th, but that the attack was not pushed home.

At an early hour on the 11th two of the enemy's torpedo boats, coming from the Channel Islands, succeeded in entering Portland Roads, and were discovered while approaching the *Belleisle.* The B vessels immediately opened a heavy fire, under which the torpedo boats withdrew. The *Grasshopper* and *Rattlesnake* started in chase, but the torpedo boats escaped. On the same day the two former vessels, which had been sent to reconnoitre Alderney and Guernsey, claimed to have put No. 45 out of action.

On the 13th two more determined attacks were made by torpedo boats, which had steamed across the channel from Alderney under cover of the darkness. The first attack was made before 1 a. m. by torpedo boat No. 58, which succeeded in entering the Roads under the lee of a merchant vessel; but when the latter hove to the former was discovered by the search light of the *Hecla.* The fleet opened fire, and the *Grasshopper* started in pursuit, but the torpedo boat escaped. The second attack was made about 3 a. m. by No. 54, which entered the port by keeping close in under the land. When about to attack the *Belleisle,* she was discovered by the electric light. From her position there was no escape, and No. 54 was ruled out of action for 48 hours.

On the 14th Nos. 72, 73, and 65 were ordered to Salcombe in search f the enemy's cruisers and boats, but found none. The *Rattlesnake* nd *Grasshopper* were also sent to the neighborhood of Falmouth. On he night of the 15th they encountered Nos. 55 and 57, two of the nemy's torpedo boats. Owing to the heavy sea, the latter were forced o seek shelter behind some rocks about 5 miles east of Falmouth. hey were detected by coast guardsmen, who telegraphed to the *Rattlesnake.* The latter started in pursuit at a speed of 17 knots. When o. 55 found her distance from the cruiser to be about 200 yards, she ired a torpedo with good aim; but the *Rattlesnake* by a rapid movenent contrived to avoid the weapon. The *Rattlesnake* and *Grasshopper* laimed to have put Nos. 55 and 57 out of action, but there is no evilence that it was allowed. The two cruisers, accompanied by the two oats, arrived at Plymouth the same night. A few hours later No. 52, which had been watching the movements of the A vessels, stole into the Sound and attacked the *Rattlesnake* without being exposed to a single shot in return. The umpires ruled the *Rattlesnake* out of action for 48 hours.

On the night of the 13th Nos. 68 and 79, two of four torpedo boats that left Portland Roads to cruise in the Channel as scouts, fell in with No. 51 of C fleet, apparently making towards Portland. On being discovered, the latter steamed at full speed down the Channel, hotly pursued by 68 and 79; and after a long and exciting chase No. 51 was compelled to seek refuge and was eventually captured during the night.

The principal work of B squadron consisted in guarding Portland and the Channel.

C FLEET.

The principal operations of the torpedo flotilla of this fleet have been described, as they are intimately connected with those of A fleet and B squadron. Two minor attacks occurred also, which are worthy of mention. The *Narcissus* had put into Devonport to repair her steam pipe. At 3 a. m. on the 14th, Nos. 55 and 57 steamed up the harbor and discharged their torpedoes at this vessel without even being observed until it was too late to attempt any defense. The two Whiteheads struck the *Narcissus.* On the same night Nos. 59 and 81 were employed in harassing the colliers in Falmouth Harbor; during their operations No. 81 struck the side of No. 59 with sufficient force to cut her down from the bulwarks nearly to the keel. The latter was able, however, to make her way at 6 knots to Devonport dockyard.

Precisely at 5 p. m. on the 8th the C fleet weighed and, passing into Bantry Bay from the east end of Berehaven, stood to the eastward. The weather was hazy, with a fresh breeze and moderate sea. The *Arethusa* was sent ahead as scout. The *Neptune*, being slow and consuming much coal, was ordered to remain in Berehaven with her torpedo nettings out, prepared to resist torpedo-boat attacks. The *Ruby*, previous to the departure of the main fleet, had been sent to visit the coast-guard stations and keep them on the alert until its return, sho she be able to evade capture by A cruisers.

Clear of the land, the course was changed to southwest and the fl bore away towards Madeira. On leaving the anchorage the Vic Admiral's flagship, *Camperdown*, led the starboard, and the Rear-Adm ral's flagship, the *Minotaur*, the port division. Three of the collier whose cargoes were unbroken, steamed between the lines of the tw divisions. Going about 9 knots an hour, the fleet ran steadily to th southward the whole night. The only incident that marked the n was the appearance of a bark, at which, being mistaken in the h for one of the A cruisers, two guns were fired from the *Camperdow*

At daylight on the 9th the wind had freshened and the sea was runnin high, making the colliers pitch and roll tremendously, while checkin their speed. Signals were made that the *Camperdown*, *Howe*, an *Immortalité* should each take a collier in tow. When, after 2 hours work, the wire hawsers of the *Howe* had been secured on board th collier *Britannia* and the other men of-war were still struggling to g theirs made fast to their tows, the Vice-Admiral ordered that the col liers be cast adrift. Rain was falling and the waves were rolling highe than ever; so, leaving the colliers to run along at 7 knots or less an hour, the ships of the starboard division, steaming 11 knots, started to overtake the other and slower portion of O fleet, which, using sail as well as engines, were 10 miles ahead.

While taking the colliers in tow, the *Barrosa* had gotten out of sight. At midnight the *Immortalité* was ordered to return and find the *Ar-* *thusa* and colliers, and direct them to make all speed to the rendezvou which for the 18th was fixed at latitude 30° north, longitude 32° wes If the *Barrosa* were met on the way she was to stand by the collier whilst the *Arethusa* and *Immortalité* were to rejoin the fleet. The *Bar-* *rosa* eventually took charge of the colliers and convoyed them to th rendezvous.

On the 10th the weather had moderated, and by noon of the 12t the fleet had run to latitude 40° 33′ north, longitude 17° 30′ west Neither the *Arethusa* nor the *Immortalité* had yet rejoined the fleet. In the forenoon, to save coal, the *Tartar* was taken in tow by the *Howe* and the *Serpent* by the *Camperdown*. Steaming 9 knots with their tows th two battleships soon overhauled the rest of the fleet, although the *Min-* *taur*, *Northampton*, and *Iron Duke* had their sails set, the breeze, though light, being westerly and favorable.

At 8 a. m. on the 14th the fleet was within 30 miles of the colliers first rendezvous, which was directly off Terceira Island, Azores, at distance exceeding 5 miles. The *Forth* was sent ahead as scout, with the *Medea* somewhat in rear. There was no sign, however, of eithe the enemy or colliers. Signal was made that the *Audacious* had sprung a leak. The *Conqueror* sent her divers on board to assist in ascertain ing the nature of the leak. Speed was reduced on the rest of the fle to 4 knots while the search was in progress. It was soon found that the *Audacious* was leaking near the stern-post, as she had done during the manœuvres of 1889 under the strain of the fire of her own guns.

Early on the 15th the *Arethusa* and *Immortalité* rejoined, bringing news that the *Barrosa* had been found and left in charge of the three colliers. These two cruisers not finding the fleet at the rendezvous of latitude 35° north, longitude 22° west, the colliers had gone on to the next meeting place, latitude 33° north, longitude 32° west, and in the event of not finding the fleet there they would proceed to the last rendezvous, latitude 30° north, longitude 32° west. The coal on several of the heavier ships was running short; and to meet this contingency the *Aurora* and *Forth* were ordered to go ahead, find the colliers, and, if possible, have them at the rendezvous, latitude 32° north, longitude 32° west, by the 17th at 6 p. m., when the fleet would arrive and proceed to coal in midocean.

Up to the 14th the speed of the fleet was 8 to 9 knots; after that date it was reduced to 6½ knots. After sunset on the 17th, by means of electric-light flashes the *Aurora* and *Forth* were communicated with, although they were 15 miles ahead. They signaled that the *Barrosa* and colliers were close by; at midnight the fleet overhauled the latter but continued its course with them to the rendezvous, which was reached at 5 o'clock next morning. The log of distances since leaving Bantry Bay had been for each day, respectively, 140, 231, 192, 194, 206, 177, 140, 152, 155, 123 miles, in all 1,710 miles. The tow lines of the *Tartar* and *Serpent* were cast off and the fleet lay idle for several hours. Signal was afterwards made that coaling should begin, each vessel taking enough to steam to England. The total amount of coal taken in was 1,226 tons, distributed as follows:

Vessel.	Tons.	Hours.
Minotaur	250	14¼
Iron Duke	150	7¾
Audacious	318	26½
Ajax	310	18¼
Northampton	170	10¾
Barrosa	28	4

The *Minotaur* did not begin coaling till 4 p. m., and working by electric ght finished on the morning of the 19th. The weather was fine.

Hostilities ceased on the previous day at 5 p. m., when leaving the x ships above named to complete their coaling, the Vice-Admiral pro- eded with the rest of the fleet towards St. Miguel, Azores, being ined there by the former on the 22d. On the 26th the fleet reached ngland.

LANDING OF WOUNDED.

The conclusion of the manœuvres was made the occasion of tes the means available at the home ports for the landing and conveya to the Naval Hospitals of the wounded likely to arrive after a gen engagement with the enemy and of ascertaining what arrangem should be made at short notice for effecting these operations.

On the 16th August instructions were sent to officers comman fleets to assign to each ship under orders to return to Portsm Devonport, or the Medway an assumed number of wounded offic wounded men. Each ship on reaching her port was immediat make known by signal the number of assumed wounded on bo quiring hospital treatment, and the numbers signaled were to be ac ready for landing under suitable medical precautions. The Comma in-Chief of the three home commands were also directed on the 1 make the necessary arrangements for the landing and recepti hospital of the indicated numbers of officers and men.

The number of assumed wounded in the manœuvre fleets was and they were assigned to the several ports as follows: To Portsm 293; to Devonport, 544; to Chatham, 612. When the fleets asse at the completion of the manœuvres the mobilized ships were insp and after inspection each ship was sent to her port of commissi

The Commander-in-Chief at Portsmouth reported that had a ships arrived simultaneously the assumed wounded could all have landed expeditiously and easily. The Commander-in-Chief at D port reported that had all reached his port at the same time would have been necessary to hire tugs and boats, but that th could at all times be procured. The Commander-in-Chief at Sh ness (Chatham) reported that the *Wildfire* and the dockyard tugs launches could convey in one trip 246 patients in fine weather, or weather necessitating all being under cover, 87; whilst many sh could transport their own wounded. As a matter of fact the mean conveyance were more than sufficient for the numbers arriving at one time in ships returning from the manœuvres. It was repor generally that, even where existing hospital accommodations would have sufficed for the number of officers and men assumed to be wound special arrangements could have been made for their reception wh would have admitted of their being at least temporarily accommoda At all the ports an increase of the hospital personnel would have b necessary.

Liverpool
The Wash

UMPIRES' REPORTS AND DECISIONS.

TORPEDO-BOAT ATTACK ON A FLEET.

The under-mentioned ships are claimed and were admittedly struck by torpedoes:

No. of torpedo boat.	Ship struck.	Time under fire.
1	Inconstant (twice)	No time given.
8	....do	One shot only fired before torpedo discharged.
1	Northumberland	Not fired at before torpedo had struck.
5	Black Prince	Only while steaming from 300 to 250 yards.
7	Invincible (twice)	Only three rifles before torpedo discharged; 200 yards.
5	....do	1¼ minutes.

NOTE.—According to the reports from A fleet, the *Anson*, which is not claimed by the attack, was also hit.

The evidence as contained in the reports from the two sides is, however, quite irreconcilable; for, whereas the narratives forwarded by Commander Barry, of the *Curlew*, from the officers of the attacking flotilla distinctly affirm in the case of the several attacks that the boats were absolutely in the sound and struck with their torpedoes the several vessels claimed before any effective fire was brought to bear upon them,* the captains and officers of the watch of ten out of twelve of the vessels of the fleet report that the flotilla was under fire within the specified range for a period of 7 minutes, according to the *Northumberland*, to 3 minutes, according to the *Triumph*, before they fired their torpedoes.

The limit of time in which a torpedo boat may be under fire within the specified range of 2,000 yards being 2½ minutes, it is under these circumstances manifestly impossible for the umpires to come to any definite decision on the merits of the claims made by C fleet on the vessels named.

GENERAL REPORT OF UMPIRES.

ADMIRALTY, CRAIG'S COURT,
September 3, 1890.

SIR: With reference to your letter of the 11th July last, M. 1636, we have the honor to submit herewith our report on the 1890 naval manœuvres.

The principal object of the 1890 manœuvres was to ascertain under what conditions a hostile fleet could maintain itself on an important trade route, and interrupt the traffic, always endeavoring to avoid a general engagement.

This was done by C fleet for about 8 days, under the conditions mentioned in the report of the Admiral commanding.

The A (British) fleet did not bring the hostile fleet to action or compel it to return to port. The two fleets were never within 300 miles of each other, and at the conclusion of hostilities were 1,700 miles apart.

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*This is to a great measure corroborated by the report of the signalmen on the breakwater fort, who state that the torpedo boats were inside the breakwater before they were seen.

Information as to the most advantageous methods of employing a considerable body of scouting cruisers has been clearly shown by the operations of A fleet.

The Admiral commanding C fleet does not appear to have considered this a primary object, as shown by the disposition of his cruisers and main fleet.

No opportunity occurred for the reserve (B) fleet to contribute to the support of the main British fleet.

We consider that B fleet succeeded in protecting itself against torpedo-boat attack.

The tactics of the torpedo-boat flotilla operating from Alderney, as a distant base, were well planned and efficiently carried out during the early part of the manœuvres (notably in the attack upon A fleet in Plymouth Sound on the night of the 8th-9th August) but afterwards we consider they were not so successful, owing to their many deviations from the rules laid down for the conduct of the war, in the operations carried on in the neighborhood of Falmouth, when such use was made of the enemy's ports as could not have been possible in war.

This practice was especially irregular in the case of torpedo boats Nos. 86 and 87 when taking shelter under a coast-guard station in the Helford River for some hours in daylight and subsequently in an attack on colliers in Falmouth Harbor from that base.

A table of the claims made by the opposing fleets, with our decisions, is inclosed herewith.

We have, etc.,

W. M. DOWELL,
Admiral and Chief Umpire.
FREDK. W. RICHARDS,
Vice-Admiral.
ROBT. O. B. FITZ ROY,
Rear-Admiral.

The SECRETARY TO THE ADMIRALTY.

TABLE OF CLAIMS.

Date.	From whom.	Claim.	Umpires' decision.
Aug. 8.	Alderney and Queenstown.	Sinking of *Rattlesnake* for illegal entry into Alderney Harbor.	Disallowed.
Aug. 9.	....do	*Northumberland, Invincible, Black Prince, Inconstant,* torpedoed during attack by flotilla upon A fleet in Plymouth Sound.	Evidence too conflicting to admit of decision being arrived at.
	Admiral Tryon, Plymouth.	The whole of the torpedo flotilla as out of action before they reached the sound.	Evidence too conflicting to admit of decision being arrived at, but 51 and 82, damaged in attack, allowed as captures.
Aug. 10.	Alderney and Queenstown.	Second attack by torpedo boats on *Invincible* and *Inconstant*.	This was part of the original attack. Decision contained in first report of umpires.
Aug. 11.	Alderney	Sinking of *Grasshopper* for attempted entry into Alderney.	Disallowed.
	....do	One of B squadron's torpedo boats sunk by her own side.	Do.
Aug. 12.	Alderney and Queenstown.	Capture of five colliers, *Speedwell* and *Hearty*, by torpedo boats 86 and 87, Falmouth.	Claims from both sides disallowed.
	Falmouth	Capture of torpedo boats 86 and 87, by *Speedwell* and *Hearty*.	
Aug. 13.	Alderney	*Narcissus* torpedoed by Nos. 55 and 57 in Hamoaze.	Disallowed.
	....do	Capture of colliers at Falmouth by No. 87.	Do.

TABLE OF CLAIMS—Continued.

Date.	From whom.	Claim.	Umpires' decision.
Aug. 14.	Portland and Falmouth....	Capture of No. 51 by Nos. 68 and 79...	Allowed.
	Alderney	Capture of three colliers by Nos. 59 and 81, at Falmouth.	Disallowed.
Aug. 15.	....do	Capture of two colliers at Plymouth by No. 81.	Do.
Aug. 16.	Portland......................	*Active* claims No. 58 for unsuccessful torpedo attack.	Allowed.
	....do	*Rattlesnake* claims torpedo boat 52, as captured in Plymouth Sound.	Disallowed.
	Alderney	No. 52 claims *Rattlesnake*, as torpedoed in Plymouth Sound.	Allowed.

CASUALTIES.

The *Thames* broke down during her steam trials near Devonport. The rod of the circulating pump was completely fractured.

Torpedo boats Nos. 45 and 58, commissioned at Devonport, had to return to the dock-yard for repairs on account of the leakage of boiler tubes; No. 58 broke down a second time before she was able to proceed.

As the *Medea* was leaving Sheerness for the Downs to join the Reserve squadron, the steam pipe cracked.

The *Galatea* arrived at Plymouth on the 29th of July with her feed pump injured. On the same day No. 78, torpedo boat, was towed to Sheerness in a disabled condition, her boilers leaking badly. No. 79 towed her to Sheerness, and, on the way back to the Downs, struck bottom and damaged two of her own propeller blades. A new propeller had to be fitted.

The steering-gear of the *Gorgon* broke down about the 31st of July; and the *Hydra* also reported an accident to her machinery, which, however, was soon repaired.

On the 31st July, torpedo boat No. 85 suffered a breakdown in her machinery and had to put back to Dover.

On the 1st August, an accident to the engines caused the *Inflexible* to haul out of line; on the same day the hydraulic gear of two of her four 80-ton guns was disabled at the first round fired. She was sent into port for repairs.

On the 2d August, one of the 44-ton guns of the *Hero* came to grief in a similar way. The gun was put out of action for 6 hours.

The *Inflexible* seems to have been regarded as the lame duck of the fleet during the preliminary exercises; not that she developed serious defects, but her liability to little troubles with engines and steering-gear frequently caused her to fall out of line.

The *Ruby* broke down during the preliminary drills and had to resort to sails and the assistance of the *Ajax;* 2 or 3 hours afterwards she took her position in line.

Minor breakdowns occurred on board the *Thames* and *Mersey;* and orders were given that no vessels of the *Mohawk* class were to use forced draft, as it was found that they did not stand the test sufficiently.

During the preliminary cruise the *Mohawk* had a most unusual experience; it seems that a jelly-fish blocked up the inlet to the circulating pump, thus preventing the water from flowing into the condensers, and it was found necessary to send a diver down to remove the obstruction.

The *Rodney* left the British fleet on the 5th August on account of a crack in her steam pipe. She repaired at Plymouth.

At a late hour on the night of the 7th, torpedo boat No. 84 was run into by the steam launch of the *Belleisle* while some experiments were making with the electric light of the *Belleisle* and one of the other torpedo boats. She was cut through to the keel on the quarter.

Torpedo boat No. 82 received much damage through a collision with the *Black Prince* in Plymouth Sound on the 9th August, and was patched up with a false bow, consisting of blocks of fir weighing upwards of a ton.

No. 81 entered Plymouth on the 14th with her steering gear damaged and her boiler out of order.

On the night of the 13th, torpedo boat No. 59 was cut down by No. 81, and had to put into Plymouth.

The *Ruby* collided with an Aberdeen trawler on the afternoon of the 14th. On the same day the *Narcissus* arrived at Plymouth with steam pipes leaking; also torpedo boat No. 72 with propeller broken off, and in place of which a new one was sent from the *Hecla.*

Torpedo boat No. 86 put into Devonport on the 15th for repairs, having been damaged in a gale.

Torpedo boat No. 51 went ashore on Plymouth breakwater early on the morning of the 18th; on being docked, two or three holes were found and her propeller was much bent.

COMMENTS.

Neither fleet sighted the other during the manœuvres, and, for the greater part of the war they were absolutely ignorant of one another's whereabouts. The manœuvring, chasing, and fights, which bring the seamanlike qualities of officers to the front and afford a test of ability, clever handling, and resource, were entirely absent from the proceedings of the main fleets; and such training and experience as fell to the lot of the officers and men were given in the preliminary cruise.

The General Idea set forth that the hostile fleet should take up such a position on the trade route as its Commander-in-Chief should consider most suitable for ascertaining under what conditions it could maintain itself and interrupt the traffic, always endeavoring to avoid a general engagement. Why the British Admiral did not look for and drive in his adversary, but contented himself that his foe was not in any part of the route where trade would be most concentrated, and therefore where the presence of a hostile fleet would be most effective, and why he then remained for positive intelligence of his enemy's movements, is best explained by the following memorandum, issued to his second in command and to the captains of his ships before the operations had commenced:

> NORTHUMBERLAND, AT SEA, *August* 5, 1890.
>
> A little consideration of the printed paper of rules, entitled "The 1890 Manœuvres," will show that if an opponent elects to steer in the first instance for a position within the trade route approximately 140 miles to the southwestward of Scilly, that is, equidistant from Berehaven and Plymouth, then to steer a course with Plymouth right astern, he will continue on the trade route, and distance Plymouth every mile he goes, and not distance Berehaven to a corresponding extent; and therefore, as he has 24 hours start, even if I go at once to that spot, the speed and coal endurance of the two fleets being approximately equal, by no possibility can he be overtaken by us. For him to do so would be strictly within the rules as I read them, but it would hardly be a sporting course to adopt from a peace manœuvre's point of view, though it would be very damaging to trade and commerce. It is open to me to assume that he will do so, but that at some time or other he would return to Berehaven to coal, and I might take up a position off that port, having first reached the Shannon, a defended port, but open to torpedo attack; but I have no torpedo boats with which to disturb him there. But should he hear through a cruiser, as he easily might and probably would, that I had adopted such a course, it would be open to him simply to rest on the trade route and save coal during the whole time of the manœuvres, and to return at leisure subsequently to Torbay. I therefore reject both of the above propositions; the first, because it can not be met; the second, because it would abandon everything to his force. It remains to see what he will do to help us, and I rely on our cruisers and a vigilant lookout to avail ourselves of any opportunities that may be presented.
>
> G. TRYON,
> *Vice-Admiral.*

Of the courses open to him, then, the British Commander-in-Chief adopted a watching and waiting policy; while, on the other hand, the hostile Admiral took a line of action strictly within the rules, though, as his adversary put it, hardly a sporting one.

Generally speaking, the manœuvres were not considered to have ended very satisfactorily. The results obtained were not altogether commensurate with the forces in operation. When two powerful fleets are sent to sea as opposing forces under commanders who are furnished with instructions designed to throw light on important strategical problems, their operations must result in obtaining experience of great incidental value; but, in itself, it can not be regarded as a satisfactory result that, as the umpires put it, "the two fleets were never within 300 miles of each other, and at the conclusion of hostilities were 1,700 miles apart."

The C Fleet struck the trade route at midnight on the 10th of August, at a point where it was 180 miles wide, and where no concentration of traffic could be looked for. From this point it steamed along until, at the close of the operations, it was at a point beyond the Azores, where

FRANCE.

At 7:30 a. m., June 20, the Minister of Marine telegraphed the Superintendents of Dockyards at Cherbourg, Brest, Lorient and Rochefort to mobilize the following vessels for manoeuvres with the Mediterranean squadron and the Armored Division of the North:

At Cherbourg, the *Nielly* and the torpedo boats *Dehorter*, Nos. 66, 70, 71, and 72.

At Brest, the *Sfax*, *Primauguet*, *Rigault de Genouilly*, and torpedo boat No. 73.

At Lorient, torpedo boat No. 69.

At Rochefort, torpedo boat No. 74.

All these vessels belong to the Reserve.

The two squadrons were ordered to assemble at Brest on the 1st of July. Their composition was as follows:

MEDITERRANEAN SQUADRON.

Vice-Admiral CHARLES DUPERRÉ, Commander-in-Chief.

First Division: *Formidable*, *Amiral Baudin*, and *Amiral Duperré*, battle ships; *Vautour*, protected cruiser; *Nielly*, unprotected cruiser; *Dragonne*, torpedo vessel, and three torpedo boats, one being No. 70.

Second Division (Rear-Admiral Alquier, Commanding): *Trident*, *Courbet*, and *Redoutable*, battle ships; *Milan* and *Primauguet*, unprotected cruisers; *Dague*, torpedo vessel; and three torpedo boats, two being Nos. 69 and 72.

Third Division (Rear-Admiral O'Neill, Commanding): *Bayard*, *Duguesclin*, and *Vauban*, armored cruisers; *Forbin*, protected cruiser; *Rigault de Genouilly*, unprotected cruiser; *Bombe*, torpedo vessel, and three torpedo boats, two being the *Edmond Fontaine* and No. 74.

ARMORED DIVISION OF THE NORTH.

Rear-Admiral GERVAIS, Commander-in-Chief.

Marengo and *Requin*, battle ships; *Furieux*, coast defense vessel; *Sfax* and *Epervier*, protected cruisers; *Couleuvrine*, torpedo vessel, and torpedo boats *Dehorter*, Nos. 66 and 128.

In all thirty-six vessels, twelve of which were armored.

An accident occuring to the *Nielly*, near Batz Island, the *Forfait* was ordered to take her place.

En route to Brest the Mediterranean squadron was to manœuvre in the passages of the Balearic Islands. It left Toulon on the morning of the 15th of June; while getting under way the *Forbin* broke a piston rod and therefore made the passage to Oran under one engine.

On the evening of the 15th, the *Vautour*, *Milan*, and *Forbin* were directed to proceed on the duty assigned them, which was that one should take position between Cape San Antonio and Ivica; the second between Ivica and Caprera, the third between Caprera and Minorca, and to await the arrival of the fleet, whose three divisions were to pass one by the San Antonio-Ivica channel, another by Ivica-Caprera, the third by Caprera-Minorca. Supposed bearers of dispatches from Algiers, they could gain intelligence from merchant ships, and, if unsuccessful, were to meet the flagship at 3 p. m. on the 17th, at a prearranged rendezvous. The *Milan* and *Vautour* could not leave, but the *Forbin* was detained by her accident.

About 10 a. m., next day, the three divisions separated for the stations assigned them. They met at the appointed time at the rendezvous; but the *Vautour* was the only dispatch vessel to meet her division.

On the 22nd, after a short stay at Oran, the squadron passed through the Straits of Gibraltar; and on the 2nd of July it reached Brest, where the Armored Division of the North passed under the orders of Admiral Duperré.

This fleet now formed four squadrons as follows:

First squadron (Vice-Admiral Charles Duperré, Commander-in-Chief): *Formidable*, *Duperré*, *Courbet*, battle ships; *Sfax* and *Forbin*, protected cruisers; *Dragonne*, torpedo vessel; *Edmond-Fontaine*, Nos. 69 and 73, torpedo boats.

Second squadron (Rear-Admiral Gervais commanding): *Marengo* and *Requin*, battle ships; *Furieux*, coast-defense vessel; *Epervier*, protected cruiser; *Primauguet*, unprotected cruiser; *Bombe*, torpedo vessel; Nos. 70 and 128, torpedo boats.

Third squadron (Rear-Admiral Alquier commanding): *Trident*, *Amiral Baudin*, *Redoutable*, battle ships; *Vautour*, protected cruiser; *Forfait*, unprotected cruiser; *Dague*, torpedo vessel; *Dehorter*, Nos. 71 and 74, torpedo boats.

Fourth squadron (Rear-Admiral O'Neill commanding): *Bayard*, *Duguesclin*, and *Vauban*, armored cruisers; *Milan* and *Rigault-de-Genouilly*, unprotected cruisers; *Couleuvrine*, torpedo vessel; Nos. 66 and 72, torpedo boats.

The First Division consisted of the first and second squadrons; the Second, of the third and fourth. The cruisers and torpedo vessels in each division formed also its flying squadron. It will be seen that each battle ship thus had its scout and its torpedo vessel or boat.

The object in sending the Mediterranean Squadron into the Atlantic was not only to familiarize the officers and crews with conditions of weather and sea to which they were unaccustomed, but also to test the qualities of its several types of vessels. The manœuvres were to include exercises in naval tactics, and signaling at long ranges. They were divided into two periods.

FIRST PERIOD.

This period was devoted to the study of the most effective disposition of the vessels of the fleet when in search of an enemy; to determine the best positions for torpedo vessels and cruisers as scouts, and their value in discovering the bearing of hostile ships, and indicating their preparations for battle; to establish a rapid system of signaling the intelligence gained by the most advanced scouts; and the present tactical unit being a fleet of three divisions of battle ships, to ascertain practically the modifications required if a fourth division be added.

Quibéron was the rendezvous during the first period, which covered 8 days, from the 6th to the 13th of July, inclusive.

The fleet left Brest on the morning of July 6, with good weather. The formation was column of vessels by divisions, the first on the right, each column consisting of six battle ships. The *Dragonne*, *Couleuvrine*, *Dague*, and *Bombe* were in line abreast, 800 metres ahead of the divisions. The flying squadrons were in rear of their divisions. The torpedo boats flanked the battle ships.

During the day the fleet was put through several evolutions with a special view of increasing the cohesion of a force formed of so many different units, some of which, the cruisers especially, had been fitted out in haste.

In the evening the fleet anchored off Morgat, on Douarnenez Bay; at night it cleared for action without torpedo attack.

On the 7th of July it put to sea in double column, as on the previous day, with the cruisers as scouts. The distance between the columns was increased and signals were made at long distances. Towards 4 p. m. a southwest gale arose, and the torpedo boats were ordered to the Glénans anchorage under convoy of the *Forbin*. The fleet rode out the gale during the nights of the 7th and 8th.

In the search exercises the scouting radius was 1,200 metres for the dispatch vessels, 2,400 for the torpedo vessels, and 4,800 for the cruisers. The leading and rear squadrons were in column of vessels; those on the flanks were in line abreast and opposite the centre of the fleet. Later the Admiral ordered them to increase their radius to double distance. In this formation the torpedo vessels were at 4,800 and the cruisers at 9,600 meters. Including the distance between the columns of battle ships the scouts were thus spread over a diameter of 23 or 24 kilometres. On the whole, the results were considered excellent and capable of development on a larger scale, one still more suited to the needs of search. In this order the evolutions and signal exercises continued during the night. Steaming at 8 knots, head to sea, the battleships were not in exact column, but bore on each other's quarter at an angle signaled by the flagship. Two rockets, fired at intervals, indicated the position of the *Formidable*.

During these manœuvres, though a gale was blowing, the battle ships brought the sea at different angles and even abeam. They behaved well and kept their positions admirably. At daylight the torpedo vessels were used for calling in the advanced scouts; the fleet was then 8 miles south of Belle Isle light-house. At 3 p. m. it anchored off Quibéron.

On the night of the 9th there was an attack by torpedo boats; nets were lowered, and the search-lights turned on. Owing to the reflection by the fog, which it could not penetrate, the electric light prevented the steam launches and torpedo vessels on scout service from keeping an effective lookout. They were blinded by their own projectors. The gunners were favored but little more, and the torpedo boats succeeded in launching their torpedoes against the battle ships at a less distance than that prescribed by the rules.

On the 10th the fleet left Quibéron, heading towards the northwest. It executed manœuvres on opposite courses with an attack by torpedo boats. The two divisions at 600 metres distance, each in column of vessels, steamed on parallel and opposite courses, the torpedo boats keeping on the disengaged side. Those of the first division, in two groups, were behind the *Formidable* and *Amiral Duperré*, and were to attack the leading battle ships of the second division. The first group attacked the *Amiral Baudin* after having passed under the bow of the *Formidable;* the second group, going between the *Formidable* and *Duperré*, headed for the *Trident*. The attack was executed badly, and the torpedo boats remained only 3 minutes under the fire of the battleships.

In the second evolution the torpedo boats were in rear of the *Requin* and the *Furieux*. Some attacked while going about, others while pursuing the second division, in other words, after having gone about completely. But the latter attacks were not very successful.

On the 11th the divisions manœuvred, one in column of vessels, the other in line abreast. The first in column, with its torpedo boats in two groups, passed between the *Redoutable* and the *Vauban* of the second division, which were 800 metres apart. The torpedo boats, having the enemy on both sides, were much exposed and their attack was weak; but it was not so in the next evolution, where the formations were reversed. The first division in line abreast, with its torpedo boats behind the *Requin* and the *Marengo*, cut through the second division in column of vessels. Their attack was easy; they could torpedo not only the *Trident* and the *Baudin*, but also the *Redoutable* and the *Vauban*. The fleet passed the night at Hoedic anchorage. On the 12th it manœuvred in Audierne Bay and on the 13th arrived at Brest, where it provisioned and coaled on the 15th.

SECOND PERIOD.

The second period began on the 17th of July; the rules, derived from the first, were to be applied to given strategic conditions.

The General Idea was as follows: A fleet leaving Cherbourg, in time of war, is to search for and join, at the entrance to the channel, another fleet coming from Toulon, which is ignorant of the declaration of war. The combined forces, as one fleet, are to find and drive back an enemy's squadron arriving from the North Sea to attack the coast of Normandy.

The French fleet, the principal part of which was at St. Vaast-la-Hougue, was to protect Cherbourg and Havre. A squadron detached from the fleet was on the lookout at the entrance of the Strait of Dover beyond Dieppe. Its scouts were to keep the Admiral informed of the movements of the enemy. On learning of the latter's arrival, the fleet was to go rapidly to the support of the lookout squadron, and to drive the enemy's squadron into the North Sea.

PREPARATORY MANOEUVRES.

The fleet left Brest on the 17th about 10 a. m., in double column by divisions, the first on the right, the flying squadrons in column of vessels behind their respective divisions. The dispatch vessels were 300 metres from the flagship and forward of her beam. Near Mengan Rock, in the entrance, the Admiral signaled to the second division "Manœuvre at will." The latter stood southward, while the first continued northward of the Rock. At 11 o'clock the fleet again formed column of vessels by divisions, the first on the right, the distance between columns being 800 metres; course S. 68° W. At 11.30 the *Milan* struck a rock and signaled that she was leaking; the hole made was 7 feet long by 3 feet wide and her pumps barely kept her afloat till she could reach the docks. The *Sfax*, *Rigault-de-Genouilly* and *Vautour* were ordered to her assistance and she returned to Brest.

The fleet continued its course. The weather was calm and clear at first, but soon became foggy. The Admiral then stood for Douarnenez Bay, where the fleet anchored at 8 p. m.

The 18th was foggy.

The weather of the 19th was fine. The cruisers exercised at target practice and in the evening there was an attack by torpedo boats. Six torpedo vessels were sent out as scouts, four of them being well advanced. The torpedo boats left at 6 p. m. and returned under cover of the land, making their attack between 9.30 and 10.30 p. m. At 9.35 firing to the southward was heard. The *Bombe* and the *Dague*, discovering the first group of torpedo boats, opened a heavy fire. It passed, nevertheless, followed by the second group; but the torpedo boats soon fell under the rays of the search-lights. They were then exposed to a possibly terrific fire; but the attack was not regarded as necessarily a failure because the fire of the fleet seems to have been wild at first, through the demoralization arising from an attack by torpedo boats.

STRATEGIC MANŒUVRES.

On the 20th of July the strategic manœuvres began. The fleet formed in two divisions.

The first weighed without its torpedo boats and stood to the northward. It was supposed to have left Cherbourg at 4 a. m., July 21. The other division stood southward and was to manœuvre as if arriving from Toulon and was to reach Cherbourg without communicating with Ushant.

It was the application on a large scale of the method of searching for an enemy, tried during the first period in the neighborhood of Quibéron. The Second Division steered towards the northwest during the night of the 20th, passing near Ushant in sight of Vièrge Island, and made Point de la Hague. On the 21st about noon, in foggy weather and Batz Island bearing abeam, the scouts of the Second Division—fleet from the Mediterranean—signaled the presence of the First Division or Channel Fleet. The combined forces stood for St. Vaast. Near the Casquets an accident occurred to the machinery of the *Epervier*, and she returned to Cherbourg escorted by the *Primauguet*. The torpedo boats had rendezvoused at Cherbourg; the *Edmond-Fontaine* and *No.* 128 were the only ones to join the fleet at St. Vaast.

The enemy was represented by the *Primauguet* and the *Rigault-de-Genouilly*. The French lookout squadron under Rear-Admiral Gervais consisted of the *Marengo*, *Requin*, *Furieux*, *Sfax*, *Vautour*, *Forfait*, and torpedo boats *No.* 128 and *Edmond-Fontaine*. It got under way at 11 p. m. of the 22d. The rest of the fleet remained at anchor during the 23d, covering at once Cherbourg and Havre. The dispatch vessels were the advanced scouts, on a circle of 2½ miles radius from the squadron. During the night the *Milan* was detailed to keep up communication between the scouts and the fleet. The latter was cleared for action.

About 6 a. m. on the 24th, the *Vautour* brought intelligence that the lookout squadron had sighted the enemy.

The fleet weighed at once, formed in column of vessels, speed 8 knots; the *Forbin*, *Milan*, and *Vautour* were abreast the column. The speed was increased to 10½ knots; then the *Forbin* was ordered to chase the suspicious vessels, keeping the flagship in sight. The Admiral signaled to form line abreast, the intervals between the battle ships to be 1,000 metres, the *Amiral-Baudin* being guide-ship. On coming up with the lookout division, the latter formed a reserve squadron in rear of the fleet. The *Courbet* and *Redoutable* were then ordered to chase the enemy.

About 10 a. m. the fleet stood for St. Vaast; on the 25th it entered Cherbourg. As an end to the manœuvres, Cherbourg was bombarded, the passes forced, and the fleet was attacked by the torpedo-boats cooperating with the mobile defense of the port.

CASUALTIES.

The accidents to the *Nielly*, *Forbin*, and *Milan* have been mentioned. On the evening of the 17th, the *Dague's* feed pumps broke down and she was taken in tow by the *Milan*, which took her to Oran.

At 10 a. m. on the 22d, the *Vauban* had to leave the line because of hot bearings. In the evening the steering gear of the *Courbet* carried away; it was not replaced till the following morning.

On the 26th, leaks occurred in the boiler tubes of the *Couleuvrine*; and on the 27th she was taken in tow by the *Redoutable*. On the same day the *Dague's* feed pump again broke down, and the *Courbet* took her in tow, where she remained till in sight of Ile de Groix. After the *Couleuvrine* and the *Dague*, the *Vautour* signaled an accident; she was left to the care of the *Bayard* and did not rejoin the squadron till 3 o'clock in the morning. It was finally the *Trident* which in her turn was obliged on the 28th to leave the line for a few hours, as she could not keep up with the fleet.

It seems that the fleet was detained at the Glénan's anchorage for 3 days making good defects in the torpedo and dispatch vessels.

On the 28th, the *Epervier's* circulating pump broke down, and she had to go into dock at Cherbourg, where her injuries were found to be so serious as to require several weeks for repairs.

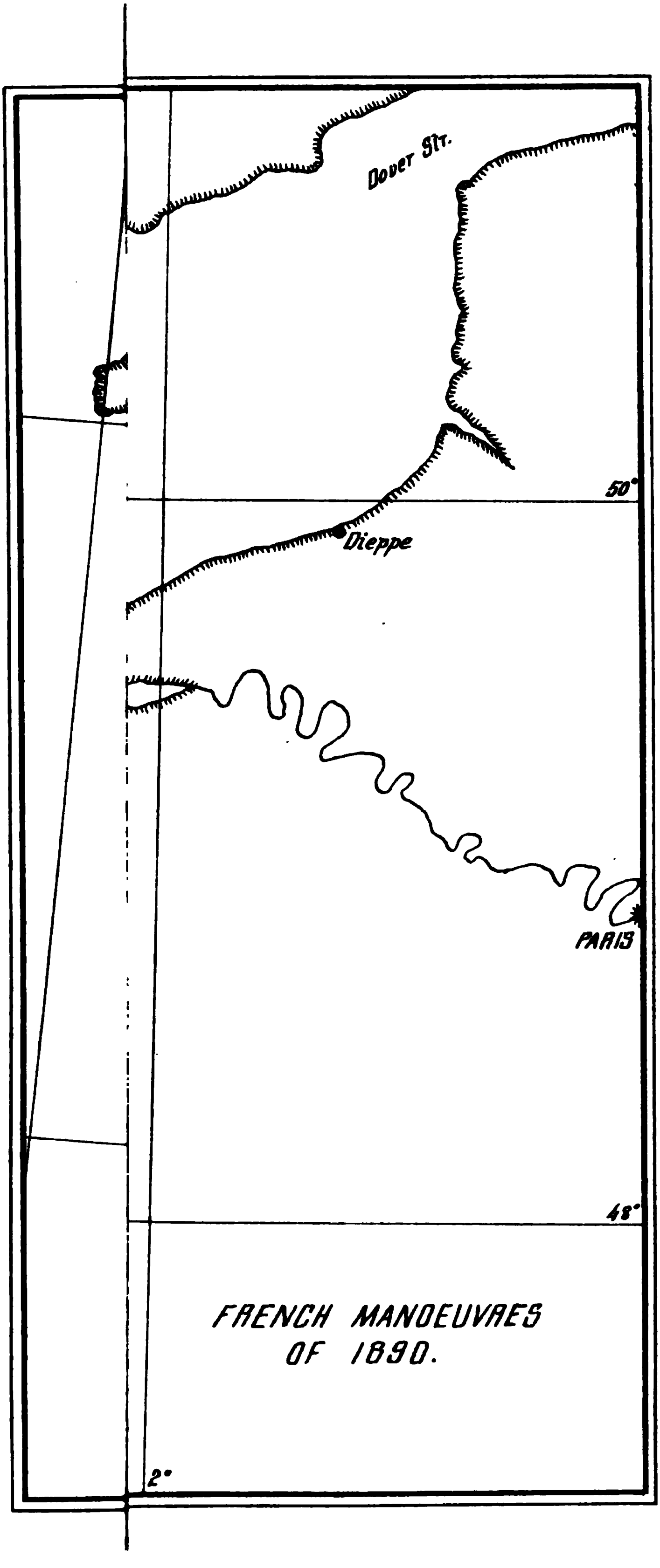
COMMENTS.

The battle ships and cruisers behaved well at sea, but the torpedo and dispatch vessels were a source of anxiety. Several times the battle ships were obliged to take some of them in tow; the manœuvres seem to prove that they have not sufficient endurance. Their very powerful and complicated engines are in small and light hulls; and in continued bad weather, which occurred during the later manœuvres, the personnel gave out constantly. During the gale of July 7 they were sent to the Glénan's anchorage under convoy of a cruiser. In good weather, however, they were very useful as scouts and as torpedo-boat catchers. They would be valuable in large bays and near the coast as the auxiliaries of cruisers that are able to keep the sea in all conditions of weather.

The method of exploration or of search for an enemy could receive greater development and one more suited to the needs of war. Its object is two fold:

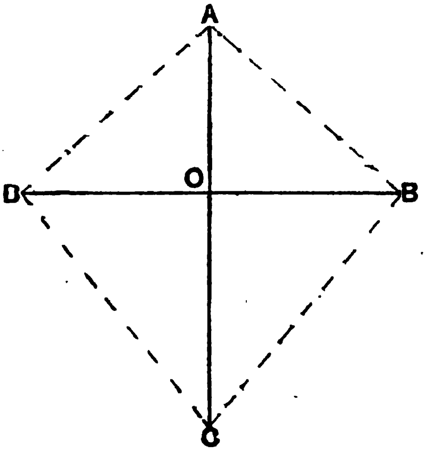
(1) To ascertain the position and disposition of the enemy, thus enabling the fleet to form in the best order of battle and at the most opportune moment. It will also increase the chance of escape if the force is not in a position to fight.

(2) To prevent the enemy's cruisers from gaining intelligence of the strength of the fleet, and to chase them before they can even sight the main squadron.



FRENCH MANOEUVRES OF 1890.

The formation of the fleet in a cross was only satisfactory when the lookout zone was within certain limits of area. As long as two successive extremities of the cross are not too far apart to prevent the circles of visibility of those points from cutting or being tangent, no hostile ship can enter the sectors AOD, DOC, etc.



But if the lookout radius be doubled (that is, become 45 or 50 kilometres), which would perhaps be desirable in practice, the length of the arms of the cross increases, the extremities are farther apart, and the sectors are larger. The circles of visibility no longer intersect, and it becomes necessary to put additional ships in the sectors for lookout service. The lozenge-shaped figure changes then to a hexagonal or circular one, and the main fleet will be surrounded by a belt of scouts. But this is not sufficient; cruisers must go successively beyond the circle to seek the enemy or to prove that he is not in a given position. It is easy then to pass from the system tried in the manœuvres to that indicated above; but a larger number of scouts will be required, and faster ones, too.

The manœuvres proved too that the principal commercial and military ports should be provided in peace with large supplies of coal for the use of the fleet in war.

They also demonstrated the fact that every ship should be able to communicate with the coast semaphone-stations; and that every cruiser or other vessel on scout service should use this means of communicating with the squadron when it is anchored in a known place. In the latter part of the strategic manœuvres it required 15 hours of direct steaming on the part of the *Vautour* to inform the Admiral of the presence of the enemy in the Channel. Fifteen minutes, or perhaps a half hour, would have been sufficient for communicating the fact to him by semaphore. If, since the detachment of the lookout squadron, the Admiral had changed his anchorage, the message could have been forwarded from Saint Waast. Fully 14 hours would have been gained.

The average speed of the battle ships, 8 knots, is too small for passing the night in the vicinity of the enemy's coast on account of the liability to attack by torpedo boats.

Ports of refuge or general strategic bases of operations on or near the coast are desirable for the defense if his battle ships are to be safe from heavy gales or are not to fear torpedo attack at night.

It is claimed for the manœuvres that the French authorities are now able to lay down precise rules for the best tactical order of battle for a fleet of modern vessels.

The addition to the fleet of a fourth division of battle ships renders its movements very slow. A very long time was necessary for getting under way: and especially in passing from column of vessels to line abreast.

The need of exercising officers and crews in handling their vessels under high speed was further emphasized by this year's operations.

The organization of the second class of Reserve was shown to be defective. Theoretically ships of this class are ready to be fitted out at once. The period given them for doing so is not intended for repairs.

The engineer's force of the Reserve is not large enough for efficient handling of the machinery.

It is claimed that a cause of mishap in the very fast ships lies in the boilers of locomotive type; and that another is due to a reduction of their speed from 12 or 14 knots, normal, to 7 or 8 knots in squadron, and even to 4 or 5 knots, head to wind. It was noticed that when these vessels were ordered, upon emergency, at high or full speed, an accident was probable and did happen to the *Epervier*.

Little could be said of the armored cruisers *Bayard*, *Vauban*, and *Duguesclin*, which may be regarded as smaller battle ships. They have hardly a serious fighting value and a French naval writer regards it as one of the main lessons of the manœuvres that they should be replaced by more powerful fighting ships.

There seems to be a concensus of opinion among French naval officers, as the result of the first period of the manœuvres, that small torpedo boats, instead of being an assistance, are a positive hindrance to a fleet, unless the weather be unusually good; and the idea is also gaining ground that the value of the torpedo, except for coast defense, has been exaggerated greatly. On the other hand, it is contended by French authorities that the machinery of the swift torpedo vessels is so complicated and requires so much study on the part of both officers and men that if the vessels are to be really useful they should never be out of commission, but should be constantly on active service, if for no other purpose than to train their crews.

GERMANY.

The autumn manœuvres of the Ninth Army Corps in Schleswig-Holstein, from September 3 to September 10, derived additional interest from the presence of the German Emperor and from the coöperation of the German fleet. They were the first combined manœuvres attempted in Germany, and, perhaps, anywhere on so extensive a scale.

The armored fleet coöperated actively with the Ninth Corps during only one day of the manœuvres, but its presence materially affected the operation of the land forces throughout the evolutions near Düppel during the 8th, 9th, and 10th of September.

On the 3d the Ninth Corps concentrated in and about Flensburg. The German Emperor arrived from Kiel in the Imperial Yacht *Hohenzollern*, escorted by the following vessels:

(1) Squadron of Evolution (Vice-Admiral Deinhard, Commander-in-Chief): *Baden* (flag), *Bayern*, *Oldenburg*, and *Würtemberg*, battle-ships; *Zieten*, dispatch and torpedo vessel.

(2) Practice squadron (Rear-Admiral Schroeder, Commander-in-Chief): *Kaiser* (flag), *Deutschland*, *Preussen*, and *Friedrich der Grosse*, battle-ships; *Irene*, practice cruiser; *Pfeil*, dispatch and torpedo vessel.

(3) Torpedo squadron: *Blitz*, dispatch vessel; division boat D_1 and six torpedo boats; division boat D_5 and six torpedo boats; division boat D_6 and six torpedo boats.

The following vessels were also present during the evolutions:

Ariadne and *Luise*, unprotected cruisers, and *Rover*, sailing brig, practice vessels for apprentices; *Niobe* (sail), practice ship for cadets.

The fleet anchored off Dockholmivick on the evening of the 3d, the *Hohenzollern* proceeding to Ekensund. The Imperial Headquarters were established in the Chateau of Gravenstein.

FLEET MANŒUVRES AND TARGET PRACTICE.

At 8 a.m. on the 6th of September the Emperor's Standard was hoisted on board the *Baden*, and the fleet stood out of the Flensburg Föhrde in double column as follows:

Left column.	Right column.
Baden,	*Kaiser*,
Oldenburg,	*Deutschland*,
Bayern,	*Preussen*,
Würtemberg,	*Friedrich der Grosse*.

It was preceded by the *Irene* and *Blitz*, with a division of torpedo boats, and followed by two divisions of boats with the *Pfeil* and *Zieten*. It remained in this formation until 6 miles from land.

The general plan of operations was as follows: Information to the effect that a hostile squadron had passed the Great Belt was telegraphed at an early hour in the morning to the Admiral in command. Thereupon the Admiral was to weigh and to stand out to sea to find and destroy the enemy. The actual enemy was only a skeleton one, and was composed of six floating targets, which were anchored at sea over night in a position unknown to the German fleet.

The *Irene* and the dispatch vessels with the three divisions of torpedo boats acted as scouts. About 10 a. m. the *Irene* returned with the intelligence "Enemy in sight!" At 10:30 passed from double column to single line, the *Baden* leading; at 10:45 the course was changed eight points to the northward and the fleet approached the line of targets. The latter were six in number, anchored about 400 yards apart in a line from north to south, and consisted, each, of two pyramids connected by a transverse frame.

When the fleet changed its course to close with the targets, the *Irene* took position astern of the last ship in line; the *Blitz* and the torpedo flotillas returned to the Föhrde. The formation adopted throughout by the torpedo divisions, except when on scout service, was the division boat leading, followed by the six torpedo boats in pairs, each pair 30° abaft its leaders and broad off the immediate leader's quarter.

During the action the range at no time exceeded 2,400 yards and was usually from 700 to 1,200. The sea was smooth, the light good and the gun platforms steady. The damage, however, was caused chiefly by machine and light-gun fire; the heavy projectiles wrought but little destruction. In general terms, the practice was fair.

After the fleet had fired at one side of the targets, it changed its course 180 degrees and passed along the other face, firing from both main and secondary batteries.

The fleet then formed in double column west of the targets and approached the latter, firing from the bow guns during the advance, and breaking through the line in this formation. In this case, each vessel masked its neighbor's bow fire in one direction, and it is not clear what this evolution was intended to effect.

Finally the fleet formed line and rammed the targets; one survived the charge and was afterwards rammed by the *Irene.*

At 2 p. m. the fleet returned to its anchorage, the *Baden* leading.

The lessons of the day are *nil*, nor was it intended perhaps that there should be any. It is stated that the ramming was conducted at full speed, which in actual warfare would be nearly as disastrous for the rammer as for the rammed. The vessels obeyed signals promptly and kept their stations admirably, the discipline was excellent, and the celerity and silence attending the work at the batteries were all that could be wished.

COMBINED MANŒUVRES, SEPTEMBER 8.

The General Idea was as follows:

On the 7th of September, a division of the Eastern Force supported by an armoured fleet has landed unexpectedly on the east coast of Alsen Island. A portion of the Western Army occupies the northern part of

Schleswig and the line from Flensburg to Hadersleben. The fleet of the WesternForce is blockaded in the harbor of Kiel; a torpedo-boat flotilla, of two divisions, accompanied by one dispatch vessel, is alone available and occupies the Flensburg Föhrde. The bridge at Sonderburg has been destroyed.

The Eighteenth Division represented the Eastern or invading force; the Seventeenth Division, the Western or defending force.

For the former it was assumed that the Eastern Division, with its advanced guard, had reached Sonderburg at 9 p. m., September 7; that, shortly before this, the tête-de-pont on the opposite shore was occupied by the enemy and the bridge destroyed; that during the night the work of rebuilding the latter was begun; that the main body was encamped at Hörup village and the armored fleet at anchor in Hörup Haff.

The General commanding the Eastern Division was ordered to take possession of Sundewitt peninsula on the 8th of September, with the assistance of the fleet.

The latter was divided into two squadrons.

First Squadron: *Baden* (flag), *Bayern*, *Wurtemberg*, *Oldenburg*, and *Zieten*.

Second Squadron: *Kaiser* (flag), *Deutschland*, *Preussen*, *Friedrich der Grosse*, *Irene*, and *Pfeil*.

The Torpedo Division consisted of Division Boat No. 6, and six torpedo boats.

The *Ariadne* and *Louise* were assumed to be armored ships with torpedo-defense nets.

It was assumed for the defense that, on hearing of the enemy's landing on Alsen Island the Western Division moved, during the afternoon of September 7, toward the Sündewitt, and that it had reached the following positions *much exhausted* and late in the evening:

The Thirty-third Brigade, on Düppel Heights, with outposts opposite Sonderburg;

The Thirty-fourth Brigade, at Auenbüll;

The Seventeenth Cavalry Division, at Uldemp;

The Train and Munition columns at Rinkenis;

The Division Headquarters, at Nübel;

The Torpedo Divisions, in the Flensburg Föhrde. They were accompanied by the *Blitz*. The First Division consisted of Division boat D_1, and six boats; the second, of Division boat D_5 and six boats.

The General commanding received intelligence during the night of the 7th–8th that Sonderburg was held by the enemy, and that a hostile fleet was lying in Horüp Haff.

At 5 a. m. on the 8th, he received the following dispatch from the Commander-in-Chief:

ALTONA, *September* 7, 11 p. m.

Hold the Sundewitt. The Third Brigade is ordered forward to assist you, and will reach Apenrade on the evening of September 8th.

N. N.

The following divisional orders were issued:

EASTERN DIVISION,
Headquarters, Sonderburg 7, IX, 10 p. m.

1. The enemy's troops hold the western shore of Alsen Sund, and are awaiting reinforcements from the north.

2. The Eighteenth Division, after effecting a junction with the fleet, will force, with the assistance of the latter, a passage at Sonderburg to-morrow morning, to the Sundewitt.

3. Pioneer Battalion No. 9 will prepare during the night four ferries which are to be ready for use at 7.45 to-morrow at designated points.

4. The Duke of Holstein Regiment (85) will be ready to embark at 7.45 to-morrow at the points indicated; after landing, Colonel Goldschmidt will at once take possession of the old bridge-head line.

5. This advance will be covered:

North of Sonderburg: By two detachments of Artillery Regiment No. 9, between Baadsagger and the Sonderburg Cemetery.

South of Sonderburg: By the armored fleet.

In the centre: By the advanced posts; Battalion No. 1, Eighty-fourth Regiment, in the houses along the water front of Sonderburg to and including the castle.

The above forces will be in position and ready to open fire by 7 a. m.

6. The main body will be brought forward by Maj. Gen. V. Lossberg from Horüp Kirche in time to follow the advanced guard, Duke of Holstein Regiment, at 8 a. m

7. The main body will cross in the following order:

First line:	Jäger Battalion, Nó. 9. Thirty-first Regiment. Mounted Batteries. Two squadrons of Sixteenth Hussars.	Major-General Von Lossberg,

Second line: Thirty-fifth Infantry Brigade, Maj.-Gen. Von Lundblad.

Third line: Artillery Regiment, No. 9.

Fourth line: Sixteenth Hussars.

The position of the first and second lines will be assigned by officers of the Staff.

7. I will be at the Castle of Sonderburg after 6.30 a. m.

8. After rebuilding the bridge, and while holding the enemy's front, I shall attack the enemy's right wing in its presumed position on the Düppel Heights, assisted by the fire of the fleet and by the Naval Brigade, landed south of the Düppel monument.

9. Trains will park east of Sonderburg on the Augustenburg road.

10. The ammunition trains will remain in their present positions.

VON SCHERFF.

WESTERN DIVISION,
Division Headquarters, Nubel, September 8, 5:30 a. m.

1. The enemy holds Sonderburg. A hostile fleet is at anchor in Hörup Haff.

2. The division will hold the Sundewitt.

3. I shall resist the attempted landing of the enemy with the aid of the torpedo-boat divisions.

4. Subdivisions of troops will remain as already indicated.

5. The Thirty-third Brigade will remain on the Düppel Heights and hold them against the enemy's advance from Sonderburg. Advance posts will remain as indicated. At Düppel Mill and on height No. 52 near Neu Fryendal the cavalry will establish observation points.

6. By 8 a. m. the Thirty-fourth Infantry Brigade will be in position west of the Stendemp; will reconnoitre and effect a junction on the Braacker Peninsula with one squadron of the torpedo division.

7. By 8 a. m. the Seventeenth Cavalry Brigade will be in position west of Wester Satrup; will reconnoitre in the direction of Alsen Sund, Alsen Föhrde, and Apenrader Föhrde.

8. By 8 a. m. the trains and columns will be on the Laggardholz-Gravenstein road; the heavy trains on the Fischbekholtz-Atzbüll road; heads of columns at the places last named.

9. I shall be at the Düppel monument after 7:30 a. m.

Count FINCK VON FINCKENSTEIN.

OPERATIONS.

At 5:30 a. m. on the 8th the torpedo boats of the Western Division were anchored off the Glücksburg wharf. They were painted black; no bright work was visible, not even on the revolving cannon. The deck tubes were trained to port and starboard, the bow tube openings remaining closed, though the water was smooth.

North of Habernis and commanding the approach from Flensburg were the three assumed ironclads, *Irene*, *Ariadne*, and *Louise*, of the Eastern Division, with a torpedo squadron in reserve.

By 7:30 a. m. the operations at Sonderburg began. The Eighty-fourth Regiment opened fire against the opposite shore, aided by the field artillery. Meanwhile part of the advanced guard of the Eastern Division was embarked and was crossing to the opposite shore. The pontoons were of iron lashed in pairs; the bow and stern were kept clear for the rowers, of which there were four on a side; each boat could carry 40 men.

No attempt was made to lay a bridge. After each pontoon had made six round trips it was assumed that sufficient time had elapsed for rebuilding the bridge; the bulk of the Eastern Army therefore crossed by the Sonderburg boat-bridge to the Sündewitt side. Under favorable conditions the Pioneer Division can lay a bridge of 400 metres at the rate of 5 metres in 90 seconds.

At 8 a. m. the fleet steamed out of Horup Haff in line abreast, forming column of vessels immediately after clearing the entrance. It swept past Sonderburg and into the Wenning Bund at moderate speed, the main and secondary batteries and top-guns pouring a terrific fire on the tête-de-pont and Düppel heights, against which no land force with field artillery could have stood for a quarter of an hour. If the fleet wished to secure a perfectly clean beach for landing, it surely did so. The right wing of the West Division promptly withdrew under cover north of the monument; the Schuetzen Battalion retired around the beach along the Wenning Bund and formed in a line south of the Düppel mill to continue later the flanking movement westward.

The fleet advanced slowly across the mouth of Alsen Sund, stopped at the tête-de-pont to watch the fight between the Holstein Regiment and advanced posts of the Thirty-third Brigade; and thereby missed the appointed time of anchorage.

By 8:30 it had moored head and stern in the Wenning Bund. At 8:40

the flagship signalled "Prepare for landing"; boats were lowered on the disengaged side. The fleet continued its fire on the Duppel heights till 8:57, when the first column of boats appeared astern of the *Baden*, followed immediately by the landing parties of the other ships.

The Wenning Bund beach varies from 75 to 250 feet in width; the approach is gradual and clear; an ordinary cutter can advance to within 30 feet of the shore.

Each landing party left its vessel in column of boats, towed by the steam launch; at 150 yards from the beach, the boats cast off and pulled in, the launches covering the advance with the fire of their boat-guns.

The Naval Brigade consisted of marines, sailors as infantry, and a medical staff; the pioneer corps was equipped and held in readiness, but was not disembarked.

Within 20 minutes after leaving the ships, this brigade had landed and formed for action without the slightest hitch or mishap; throughout the entire operation, not a single loud order or shout was heard from any quarter. The boats were beached in such positions that the crews had to wade ashore, many of them waist deep, but the quickness and neatness of formation on shore were beyond praise.

When the Naval Brigade was about half way ashore, the Western torpedo boats hove in sight, steaming at full speed around the Braacker Peninsula opposite Koppelholz. Only one division took part in this attack, the other having branched off to threaten the *Irene* and her consorts, or to attack the torpedo boats of the Eastern Division. Of the former, the two leading boats headed for the *Kaiser*, the rest for the *Baden*. It was afterwards stated semi-officially that the attack was a failure; it could scarcely be otherwise with an armored fleet and a division of torpedo boats to check the advance. The fact remains, however, that the commanding officer of the West Flotilla chose the best moment for the attack, as his enemy's vessels were in the confusion attendant on landing their men, their offensive powers were weakened, and their nets not out. The Western torpedo boats eventually withdrew to the neighborhood of Ekensund and attempted no further operations during the day.

No artillery was landed; the medical staff was very prompt with stretchers and other preparations and was quite ready to follow the advance. As the operations of the brigade would last only a few hours, no commissariat was organized.

Directly after landing, the Brigade advanced in a northerly direction, with its front towards the Düppel monument; the Schuetzen Battalion passed in the rear of it, advancing along shore with the objective of Alt Fryendal. Later both of these bodies formed the extreme left of the East Division, and were among the first organizations pushed towards Nübel and south of the road to that place from the Düppel mill. By 1:30 p. m. the Naval Brigade was withdrawn from the advanced line and sent back to its boats.

DEABUN
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Though the evolutions performed were of the simplest, yet the men were in the firing line throughout. There was no doubt or hesitation on the part of either officers or men as to what they had to do. The rushes forward in line were made with a snap and precision well worthy of their surroundings, which is saying very much. The men though young had sufficient resources in their own discipline and officer corps to pull them through any shore operation which they could be expected with reason to undertake.

The results of the day may be thus summarized: The right wing of the defense having been turned by the Eastern Force and by the overwhelming artillery fire of the fleet, the General of the Western Army made a vigorous offensive movement with the Thirty-fourth Brigade in the direction of Rackebüll and Height 45. Under cover of this advance, he withdrew his own right wing along the Nübel road, his artillery, west of Düppel, preventing too sudden an advance of the Eastern Army, while the bulk of his own forces retired towards the Atzbüll-Auenbüll line, about 5 miles west of Düppel.

COMMENTS.

The Western Army could not do more to fortify its position on Düppel Heights, especially against the probable fire of the fleet, because the defenders had reached their positions *very much exhausted*, a fact which threw out this contingency.

The Western Army could not flank the beach and demoralize the Naval Brigade on arrival, because the depth of the Wenning Bund would permit any of the light-draught vessels to destroy any battery or infantry force that took up a flanking position. The arrival of the assailant being unexpected, there was no time to lay out torpedoes in such an unfrequented bay as the Wenning Bund.

In the details of the General Idea it was assumed that the defense was in a losing fight from the start; that its positions alongshore were so swept by the fire of the fleet that no force could hold them; and that it was marking time, while waiting the arrival of assistance. Under these conditions the fleet could land a brigade to assist in driving back the Western Army, especially since it was already engaging a superior force in front. The beach was assumed perfectly clear; otherwise, landing against modern infantry fire is impossible, the forces being equal in fire discipline. The boats' crews remain helpless too long.

As a matter of fact, if a few hundred men, well supplied with ammunition, were covered by rifle-pits, whose position could not be made out by the enemy, and such force were required to withhold its fire until the moment of the boats' deployment for landing, not one of the latter would have reached the shore after 5 minutes of rapid fire. If the proper moment for opening fire were selected by the defense in such a case, it is not probable that the fire of the ships would have helped the boats.

ITALY.

The Idea of the manœuvres in Italy was to test the efficiency of the semaphore service and of the vedette stations in signaling to a fleet charged with the defense of the coast against sudden attack.

The Semaphore Service is controlled by the Ministry of Marine. It is very complete; forty-five stations have been established on the coast and the adjacent islands, while nineteen more are building. The coast fortifications are also supplied with outlying vedette and search-light stations. The rating of telegraphist has been established for this system.

A month before the manœuvres began the stations were inspected carefully and others, which are reserved for actual war, were occupied.

The ships were divided into two squadrons, as follows:

First Squadron (Admiral, the Duke of Genoa, Commander-in-Chief). *Lepanto* (flag), battle ship; *Piemonte* and *Dogali*, protected cruisers, second class; *Avvoltoio*, *Falco*, and *Nibbio*, torpedo boats, first class; and six or eight other torpedo boats, which were, perhaps, of the second class.

Second Squadron (Admiral Sambuy, Commandet-in-Chief). *Dandolo* (flag), *Duilio*, and *Lauria*, battle ships.

The First Squadron was charged with the defense. The several vessels maintained almost constant communication with the semaphores of their respective sectors of coast; when beyond signal distance, they used carrier pigeons.

The Second Squadron was the attacking force.

The zone of operations extended from Cape Mele, on the Gulf of Genoa, to the Straits of Piombino, and included the islands of the Tuscan Archipelago.

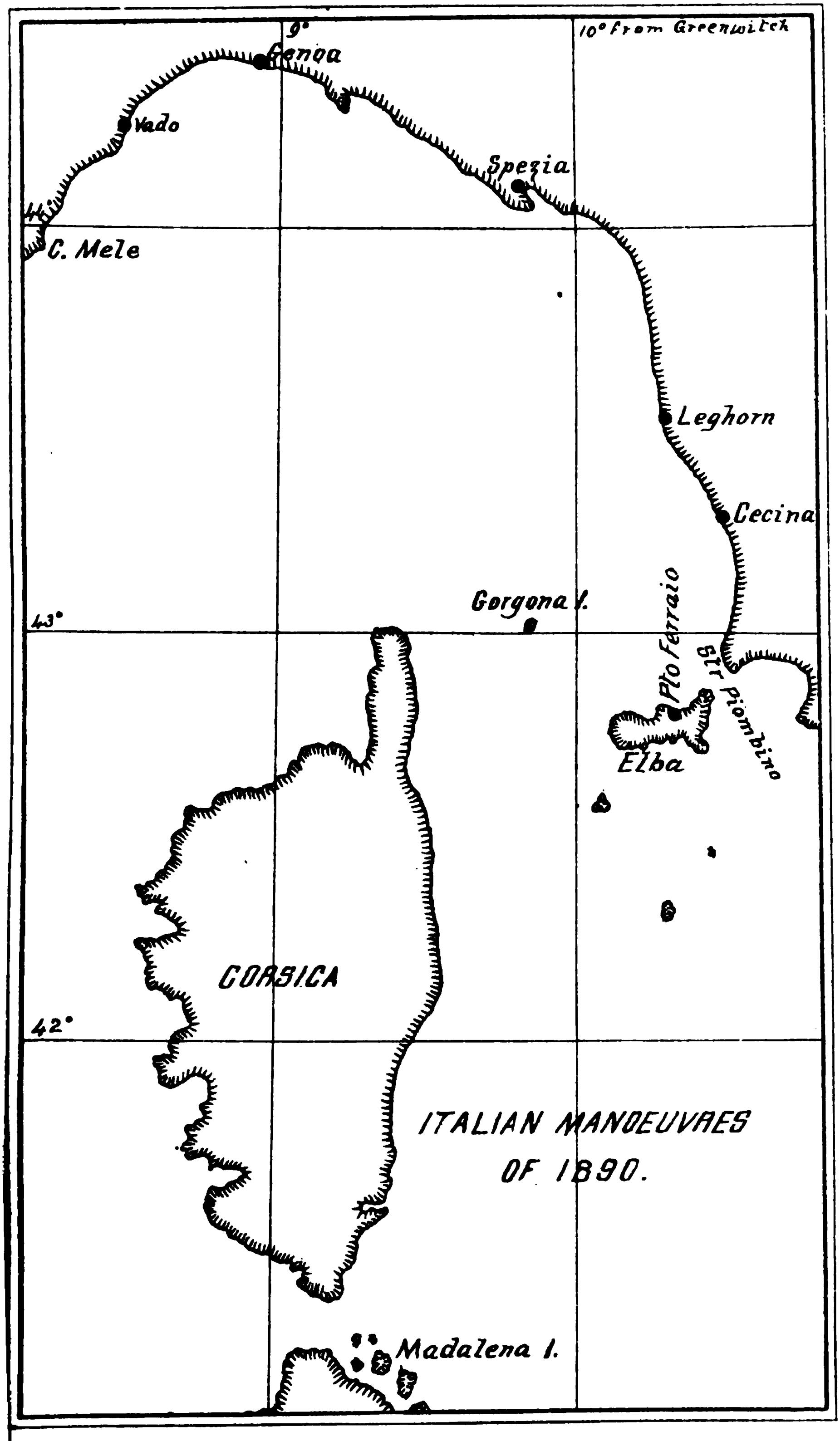
Porto Ferraio was used as a base by the First Squadron and Maddalena by the Second.

Vice-Admiral Lavera, on board the *Italia*, his flagship, acted as umpire.

Hostilities began on the morning of the 28th of July. The defense vessels were capable of good speed and were well qualified for scout service; they were deployed with a view to easy communication with the semaphores and with each other.

The first operation was an attack upon the Tuscan coast. The *Dandolo* and the *Duilio* passed to the westward of Corsica, while the *Lauria* steamed directly to the eastward. They eluded the cruisers of the defense, and the *Lauria* attacked the town of Cecina during the night; when signaled by the semaphore station, she steamed northward, arriving off Gorgona at 10 a. m. on the 29th.

On the same day at 2 p. m., the *Dandolo* and the *Duilio* passed in sight of Elba, and, favored by a fog, shaped their course for Genoa, hoping to surprise it. But at 4 o'clock the next morning, the fog lifted,



ITALIAN MANOEUVRES OF 1890.

and the two vessels discovered that they were almost surrounded by the *Lepanto*, *Piemonte*, *Dogali*, and the three first-class torpedo boats.

They ran at full speed to the southward till the limit of the zone was reached, when the chase ceased and they rejoined the *Lauria*. The three battle ships then steamed towards Vado; and, though preceded by the *Piemonte* and reported by the semaphores, they arrived there on the 31st at 1:50 p. m.; one hour later the *Lepanto* and the *Dogali* were sighted, when they ran to the southward and westward, followed by the *Piemonte*.

During the night an attempt was made to capture Spezia by surprise, but the cruisers were on the alert.

On the 1st of August the *Lepanto* was decoyed to the westward by a ruse of the *Duilio*; the *Dandolo* and the *Lauria* then forced their way through the line of cruisers and made a successful attack on Leghorn. They remained off the city until sundown, when, fearing the approach of torpedo boats, they gained an offing.

At an early hour on the morning of the 2nd, the *Dandolo* and the *Duilio* appeared off Genoa and the *Lauria* off Spezia, but were driven off by the torpedo boats and ships of the defense. They rendezvoused off Gorgona and then approached Vado, but withdrew on account of the torpedo boats.

During the manœuvres the work of the semaphore and the vedette stations and the exchange of ordinary and urgent signals between them and the vessels of the fleet were said to be very satisfactory. During the five days of war the personnel of these stations was worked day and night, and the position and movements of the attacking squadron were known continually.

The torpedo boats were used as scouts during the day and in their normal character at night. No account of accidents has been published, but all the vessels were able to keep the sea to the end of hostilities.

RUSSIA.

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The Russian naval manœuvres of last year took place between the 25th and 30th of August. The leading idea of the operations was as follows: A hostile squadron had obtained command of the Baltic and the Gulf of Riga and occupied the Moon Sound, which the enemy used as a base from which to blockade the Gulf of Finland and destroy the seaborne trade, while at the same time inflicting as much damage as possible on the seaports from Sweaborg to Bjorkö. On learning that some of the defending ships are in Sweaborg, a division of the hostile fleet is sent to blockade that harbor, while the remainder proceed eastward to carry out the designs against the Finnish coast. The defending fleet protects the principal trading ports from Sweaborg to Bjorkö and takes advantage of the separation of the hostile ships to attack the different divisions and single vessels. Finally, the defending commander breaks out of Sweaborg and the different fiörds with his fleet, and, proceeding to the Moon Sound, threatens the communications of the enemy with his base, his end and aim being to concentrate his forces by a general movement in rear of the enemy off Sweaborg.

Special attention was also to be paid during the manœuvres to testing the private signals for distinguishing friend from foe and the determining of the zone within which torpedo boats of the first and second class could be trusted to operate independently.

The attacking squadron was under the command of Vice-Admiral Kopytow, with Rear-Admiral Giers as his second in command, and consisted of the following ships:

	Displacement.	Speed.
		Knots.
The ironclad Peter Weliki	8, 749	14
The ironclad Admiral Greig	3, 593	10
The ironclad Admiral Lazarew	3, 556	10
The ironclad Admiral Spiridow	3, 740	10. 5
Corvette Rynda	2, 950	15
Clipper Strelok	1, 343	11. 5
Clipper Wjästnik	1, 256	13. 5
Torpedo cruiser Lieutenant Iljin	605	15

The first-class torpedo boats *Kotlin*, *Luga*, *Windava*, and *Sweaborg;* the transports *Krasnoja Gorka* and *Artjelschtschik*, and the schooner *Samojed.* The transports and schooner were detailed to keep the squadron supplied with coals and provisions.

The defending squadron was under the command of Rear-Admiral Gerken, and comprised the following ships:

	Tonnage.	Speed.
The ironclad *Admiral Tschitschagow*	3, 511	10. 5
Armored gunboat *Tscharodeika*	2, 020	8. 5
Armored gunboat *Smertsch*	1, 520	8
The clipper *Opritschnik*	1, 426	13
The clipper *Plastun*	1, 256	12

The gunboats *Snjeg*, *Groja*, *Doschd*, *Barja*, and *Wichr;* the first-class torpedo boats *Lachta*, *Narwa*, *Libawa*, *Wyborg;* light second-class torpedo boats 23 to 30; the transport *Ilmen*, and the schooner *Slawjanka.*

Although the leading idea of the operations was to be complied with, yet a completely free hand in taking the initiative and in carrying out their instructions was left to the respective commanders. The attacking fleet was ordered to assemble in the Moon Sound on the 24th of August; one portion of the defending force was to be at Sweaborg on the same day, the other to be in the fiörds to the eastward. The entrances from the sea to the different fiörds and the channel up to Sweaborg were considered as barred by mine-fields, in addition to which the mine-field at Rotschensalm in the channel leading to the Little Pellinge and Trangsund were supposed to be also defended by light artillery. Reval, Porkala-Udd, and Hangö-Udd were also considered as fortified and protected by mines, so that these roadsteads remained closed to the enemy. It was further contemplated that a portion of the hostile fleet should be stationed off the Tolbuchin light-ship and blockade Kronstadt, so that the route to the fortress behind the meridian of Werkömatala was barred to the defenders. The enemy was forbidden to obtain news by telegraphic dispatches, and was to trust entirely to the observations of his own ships for news of the movements of the defenders. The defending force, on the contrary, could learn all the movements of the enemy by the land telegraphs and the signal stations erected on the coast. The supplying of the ships of the attacking force with coals and provisions was to be carried out from the Moon Sound by the transports already mentioned. In the sorties of the ships and torpedo boats of the defenders from the different fiörds from midnight of the 26th to the 27th of August, all merchant ships which were met, and whose names were ascertained and entered in the log-book, were to be considered as ships of the enemy captured while conveying stores, etc., for the fleet of the latter. It was a condition, however, that the ships and vessels which took part in the sortie should not be destroyed or captured by the enemy, as in that case the prizes were also lost. If mines were laid anywhere by the enemy, in order to prevent the breaking out of the defending ships, the vessels engaged in laying the mines were to remain on the spot out of range, unobserved sufficiently long to lay the necessary number of mines to form a barrier, and in laying down the mines only that number could be counted which were actually carried on board the ships of the squadrons. There were one Umpire-in-Chief and two Umpires, each of whom was assisted by two staff officers. The commanding Admirals were directed to communicate confidentially their plans to the Umpire-in-Chief.

On the 21st of August the steamer *Onega* proceeded to Trangsund with the umpires, where the Umpire-in-Chief, Vice-Admiral Kasnakow, made himself acquainted with the plans of Rear-Admiral Gerken, commanding the defending fleet; from there he went to Helsingfors, and, embarking on the 22d of August on board the gunboat *Grosjaschtschi*, proceeded to Moonsund, in order to learn the plans of Vice-Admiral Kopytow, the commander of the enemy's squadron; he then returned to Helsingfors.

The hostile squadron on the 23d of August put to sea from Reval. On the morning of the 25th Rear-Admiral Giers was sent with the second division to the Moon Sound. This division consisted of the *Rynda* (flagship), *Wjastnik*, *Admiral Lazarew*, *Krasnaja Gorka*, and *Samojed*. The first division, under the command of Vice-Admiral Kopytow, comprising the *Peter Weliki* (flagship), *Admiral Spiridow*, *Admiral Greig*, *Strelok*, *Lieutenant Iljin*, and the *Artjelpchtschik*, remained at sea and cruised in sight of the light-houses from Packerort and Adensholm, as well as of the Moon Sound Channel. At 8 a. m. the clipper *Strelok* was sent to the Moon Sound to fetch the umpires allotted to the attacking force; she rejoined during the night with the *Krasnaja Gorka*. The torpedo boat *Windawa* served as dispatch vessel between the divisions.

The defending squadron had left Trangsund on the 23d of August, and had steamed to Helsingfors. Single vessels were stationed en route at certain points of the coast to watch the sea. In addition, mine-barriers were laid down at fourteen points between Trangsund and Helsingfors, some of which were under the protection of batteries. Six secret coaling depots for the torpedo boats were also arranged. At daybreak the torpedo boats *Lachta* and *Libawa* were sent to sea to scout; they returned, having been unobserved by the enemy, and reported the approach of three hostile ships. At 3 p. m. these were made out from the land to be the *Rynda*, one of the turret ships of the Admiral class, and the *Lieutenant Iljin;* the three ships remained in sight until midnight, but always out of range. The defending commander concluded from the movements of the three ships that they were intended to cover the route to the Moon Sound, so information was sent to the observation stations to the east of the probable movements of the enemy. The next morning it was reported that one of the enemy's transports had passed the meridian of Kalbodan Ground, steering east.

On the morning of the 26th of August, Admiral Kopytow sent the *Strelok* and the *Iljin* to scout towards the land, as, there being only a light breeze and the weather fine, an attack was expected, the other ships of the first division remaining at sea in sight of the light-house at Porkala-Udd. The defending commander, on his side, thinking that the bulk of the enemy's force was to the eastward of Helsingfors, sent the *Lachta* to reconoitre as far as the Aspö Fiörds.

From the signal station, one of the enemy's ships, the *Strelok*, was reported in sight from Sweaborg, bearing about southwest, but she remained so far out that the torpedo boat *Libawa*, which had been sent to reconnoitre, could not discover her, and at midday she was no longer to be seen from the land. The *Iljin* then hove in sight from the southward and rapidly approached; she passed the Grähara light-house, turned to the east in the channel between the reefs, and remained stopped some ten minutes. As Sweaborg is a strong fortress armed with the heaviest guns, the *Iljin* should have been considered as placed out of action, and, according to the manœuvre regulations, have abstained from hostilities for 12 hours. No umpire appears, however, to have given judgment. In any case, the entrance of the cruiser which impunity showed that the defenders were too weak afloat, for had there been more torpedo boats the *Iljin*, even if she had passed the batteries without damage, would have been attacked simultaneously from the side of the Gustarsvärd Channel and from the eastern channel to the roadstead of Hästnäs Sound. The narrowness of the channel would have precluded a retreat. The turret ship *Admiral Tschitschagow* was ordered out in chase, but something went wrong with her capstan, which delayed her weighing, so that when she arrived on the spot the cruiser had disappeared, and, an ironclad and cruiser heaving in sight from the southwest, she put back into Sweaborg.

As we have already mentioned, the *Lachta* had been sent in the morning to scout as far as the Aspö Fiörds for signs of the enemy, whose second division had in fact steamed to the east and attacked the anchorage at Aspö. The *Opritschnik*, which was scouting, observed the enemy, and reported them at 11 a. m. The fiörds were defended by the clippers *Opritschnik* and *Plastun*, the gunboats *Wichr* and *Slawjanka*, the torpedo boat *Narwa* and two second-class torpedo boats, under command of Captain Puschtschin, who weighed with his squadron and steamed as far as the Lipar light-house, but remained behind the mine defenses. As the enemy's squadron, which consisted of the *Rynda*, *Admiral Lazarew*, and the *Wjästnik*, had not attacked at midday, the *Wichr*, *Slawjanka*, and *Narwa*, returned to the inner fiörds, while the clippers steamed to Kursalö. When the enemy observed that the *Opritschnik* had passed the narrow channel on the east side of the island Woiti-Kari, he concluded that it was free from mines, and determined to enter the roadstead with his ships and destroy his weaker foe. The channels here were, however, protected by mine fields which were not removed by the enemy before he entered, so his ships were later considered as having been placed out of action; Captain Puschtschin reported, at least, that two vessels could have been blown up. The enemy on their side claimed the victory, and asserted that when entering the roadstead the *Narva* and the second-class torpedo boats would have been destroyed and that the *Wichr* had ceased firing. It appears that the *Narva* had discharged a torpedo both against the corvette and the turret ship, but without success. The manœuvre regulations laid down that if a ship passed over a hostile mine field without having searched for the mines, she was to be considered as destroyed; if, however, a squadron was in line ahead, then in narrow waters only the leading ship and in main channels the two leading ships were to be considered as blown up. The assailants moved off to the east, and Captain Puschtschin to Bjorkö, while the *Wichr* and a torpedo boat repaired the mine barrier. The *Lachta* had also returned, having reported the fighting between the two divisions, but without having taken any part herself. In the evening came the report to Sweaborg that torpedo boat No. 107 had succeeded in blowing up the *Krasnaja Gorka*, one of the enemy's transports. The enemy had, therefore, already suffered serious losses, but the ships after 12 hours would again resume hostilities. In the evening the barometer fell, and the weather became dull, with rain and thunderstorms. On August 27 bad weather set in, which lasted almost without interruption for two days, and the attacking force had rather a rough time of it. The ships remained at sea, blockading Sweaborg, but without seeing anything of their opponents. During the forenoon the weather was clear, but the wind rose; at midday it came on to blow hard, the wind veering from east-southeast to southwest with the force of the wind 10, while a heavy sea was running; in the evening the wind fell somewhat, the ships having lain to all day. The next morning the *Iljin* came in sight from Sweaborg, in consequence of the turret ship *Admiral Tschitschagow* and the two torpedo boats having put to sea to reconnoitre; the weather, however, was still hazy, and the ships put back to Sweaborg without sighting the enemy. The wind soon rose again, and the *Iljin* was observed from the land to have taken shelter behind the island Stor Mjolö. She must, therefore, have again passed over one of the mine fields, and was for the second time put out of action. In the evening five, and then six, ships were observed steaming towards Sweaborg; later they altered course to the westward, but remained within sight of the fortress. The weather was now so bad that the enemy's torpedo boats had to take shelter in Reval. The second division of the enemy had been observed during the day off Pellinge; later on they presumably came to an anchor off the Kalbodan Ground lightship. Here the *Rynda* lost an anchor stock, and the *Admiral Lazarew*, having run out of coals, had to be towed under shelter of the reefs by the *Krasnaja Gorka.* In consequence of the heavy sea, while taking her in tow, the transport collided with the ironclad, losing one of her boats and smashing her bulwarks; finally, the towing hawser carried away and fouled her screw, so she had herself to be towed in by the *Wjästnik,* while the *Admiral Lazarew* anchored and rode out the gale with 100 fathoms of chain, being eventually towed in early on the 28th by the *Rynda.* On the evening of the 27th, all the ships of the defending squadrons were at their stations; the *Tscharodeika*, *Smertsch*, *Snjeg*, and two torpedo boats in Bjorkö, to protect the coast line to Pitkopass; the *Doschd*, with one torpedo boat, from Pitkopass to Kursalö; the *Wichr* westward from Kursalö; the *Groja*, with a torpedo boat, from Digskar to Lang-Biran; and the *Opritschnik*, *Plastun*, *Slawjanka*, the *Narwa*, and two second-class torpedo boats in Aspö. Off Söderskär lay the gunboat *Barja*, with two torpedo boats. Signal stations were also erected upon the heights of Sweaborg, and all the entrances to the roadstead protected by bombs and other obstructions.

On the 28th of August the morning was dull and rainy, wind southwest, and barometer falling slowly. Two turret ships and a clipper cruised before Sweaborg; the other ships of the enemy watched the other portions of the coast of Finland. At daybreak two of the defending torpedo boats, the *Libawa* and *Lachta*, put to sea to try and destroy the enemy's transports coming from the west. The capture or destruction was, according to the orders, to be marked by the entry of the name of passing ships in the log. The *Ilmen* was sent to the east to scout, and a telegraphic order went to Bjorkö that a clipper evading the blockading squadron should be sent to search the Moonsund, the base of the enemy, and to create a diversion in his rear, so that he might be moved to raise the blockade of the fortress. The remaining ships of the left flank of the defense were to come to Sweaborg.

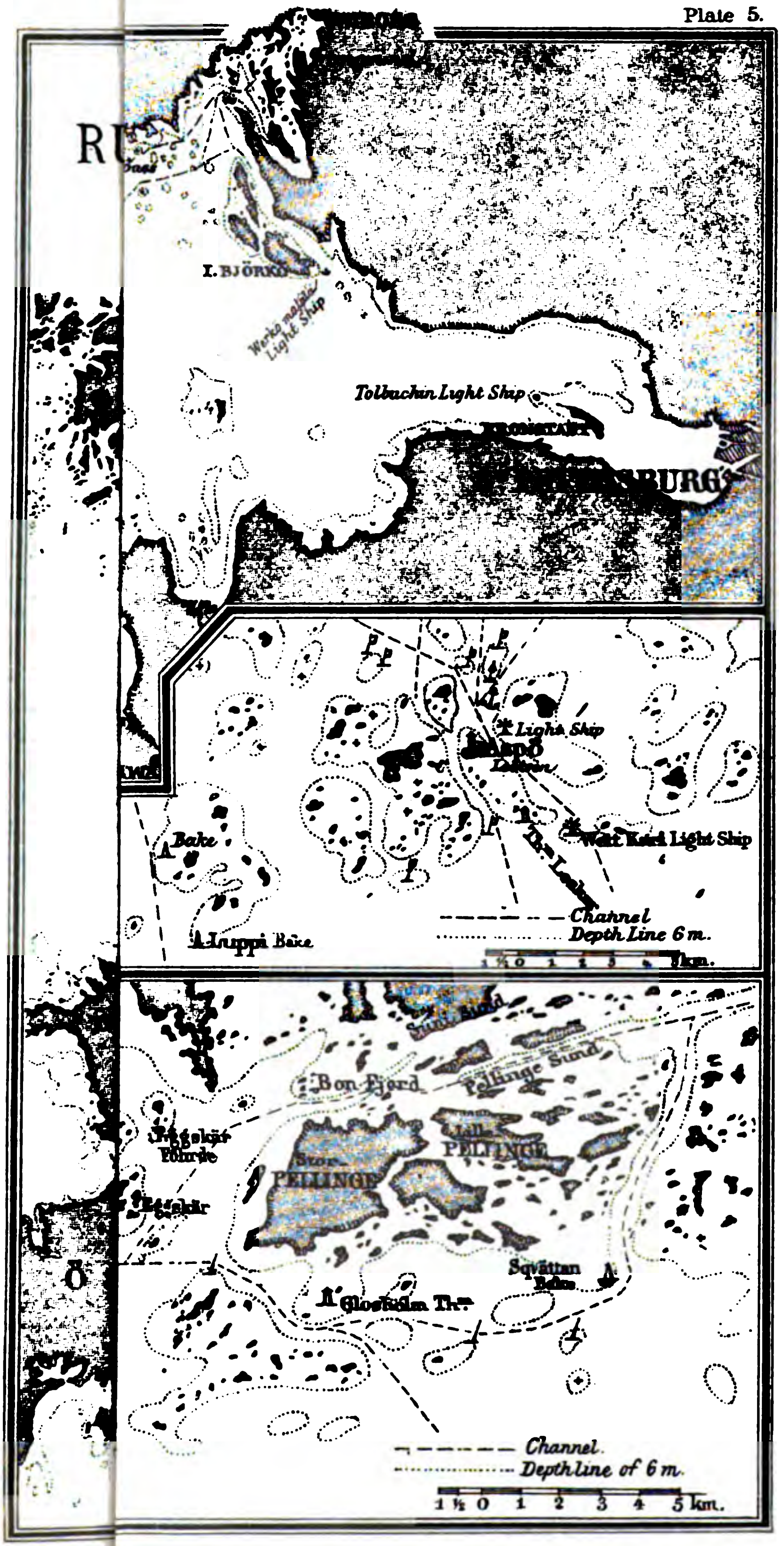
Towards midday the weather became clear and the attacking squadron approached the fortress. The turret ship *Admiral Tschitschagow* left the harbor and steamed towards the *Peter Weliki*, but did not go within range. In the afternoon it again came on to blow very hard, the force of the wind reaching 11. The ships in the roadstead of Sweaborg were compelled to let go a second anchor and get up steam. The *Lachta* lost her mast and drove, so that she was compelled to proceed to Narva-Hamn. The blockading ships had also to fight hard; the flag ship had two boats' davits carried away and the boat hanging to them destroyed; a six-oared boat was almost completely torn away, the pinnace disappeared completely, the steam cutter and another six-oared boat were damaged, and, in addition to other damage, an officer and seaman were hurt. The *Admiral Greig* sprang a small leak in consequence of the bolts of one of the armor plates slackening. With the exception of the two ships of the Admiral class no other ships of the first division suffered any damage. The ships of the defending squadron rode it out without mishap, with the exception of the *Opritschnik*, which lost all her anchors, and was compelled to put to sea under difficult circumstances. In the evening the weather got better and the night was fine.

In the morning there had been a fight between torpedo boats. The defending boats had, when they sought shelter in Borgö, found there the *Sweaborg* and *Luga*, two of the enemy's boats, which had put in there for the night on account of the gale, and also a second-class boat, No. 60, which had been captured by them, it having been sent to Borgö with dispatches. The *Sweaborg* and *Luga* immediately weighed and engaged the boats of the defending force, who had to retreat and give up their prize. No. 60 brought dispatches to the gunboat *Burja*, and was then compelled to put into the Sunnisound in order not again to fall into the hands of the enemy's torpedo boats. During the gale the second division had been off the Kokschär light-house, and had ridden the gale out without damage. Before the worst of the storm came on the torpedo cruiser *Lieutenant Iljin* had rescued 22 shipwrecked seamen from a boat and conveyed them to Helsingfors.

On the 29th of August the cruiser *Strelok*, of the attacking force, approached Gräbara and was here attacked by the defending torpedo boats; she, however, withdrew without damage. In the night, as we have already reported, the ships of the left wing of the defense had received orders to draw to the west and join the Admiral, and the clipper *Plastun*, which was in Reval, was ordered to make a diversion from the southwest, so as to draw the enemy from before Sweaborg. There was a conviction that the ships coming to Sweaborg would come across the enemy on their way, because the hostile torpedo boats had been found in Burgö, where they had made their way unobserved. In the morning the hostile squadron hove in sight of the fortress and a clipper steamed within range of the guns. The turret ship *Admiral Tschitschagow* and the *Libawa* steamed towards the enemy, the *Libawa* attacking the clipper, which had to retreat; the two ships then opened fire on the enemy at about 4,000 yards, but, failing to effect their object, at 1.30 p. m. they returned to the roadstead, the hostile squadron proceeding to Grähara, where the *Strelok* and *Luga* were blockading the other ships. From the *Luga* the Admiral learned that the second division during the gale had lain off Kotschär, and had afterwards proceeded to the northern side of the Gulf of Finland, where in the evening they were reported in the neighborhood of Glosholm light-house. The *Luga*, under a flag of truce, proceeded to Sweaborg to report that the *Ilmen* had suffered damage during the gale; she had dragged her anchor and struck on a rock, and it was requested that one of the harbor steamers should be sent to her assistance.

On the 30th of August, the last day of the manœuvres, the defending Admiral determined to attack the enemy simultaneously with all his ships. The arrangements were as follows: The *Smertsch* and *Tscharodeika*, with the torpedo boats attached to them, should leave Bjorkö and Rotschensalm and join the squadron of Captain Puschtschin. The assembled force should then make for Sweaborg, and on the morning of the 30th should attack the enemy from Rönnskär. The orders which the cruiser *Plastun* had received have already been mentioned. The attack was to commence at 10 a. m., the torpedo boats issuing from the Ugnsmun and Laugörn Channel. The *ordre de bataille*, formation for attack, private signals, etc., were communicated. Before, however, the Admiral with his ships had left Sweaborg the *Libawa*, which had been to Pellinge, reported that she had only been able to see the enemy's ships, and it must be therefore assumed that Fiörd flotilla was shut in by them. The dispositions were therefore changed. The turret ship *Admiral Tschitschagow* had already left the roadstead, and, although she sighted the enemy, she soon lost sight of them again in consequence of the thick weather; the ironclad wished, with the *Skobeleff*, which had been reconnoitring during the morning, to proceed to the eastward by the inner channel and assist the blockaded ships, but both ships had to give up the idea and return on account of the fog, and because the marks had been displaced and some destroyed by the late gale. About noon smoke was reported in the east, and the *Libawa* was again sent to scout in that direction, returning about 1 p. m. with the squadron of Captain Puschtschin and the *Plastun*, which

Plate 5.



RU
Bast
I. BJÖRKÖ
Werko matala Light Ship
Tolbuchin Light Ship
KRONSTADT
BURG
Light Ship
Bake
Luppi Bake
Light Ship
Channel
Depth Line 6 m.
½ 0 1 2 3 4 5 km.
Sund
Pellinge Sund
Bon Fjord
Lill PELLINGE
Stor PELLINGE
Sqvättan Bake
Channel
Depth line of 6 m
1 ½ 0 1 2 3 4 5 km.

latter ship had joined him at Aspö, but without the gunboats *Smertch* and *Tscharodeika*. Without these two vessels an attack on the enemy was not feasible, and the Admiral therefore returned with his whole squadron to the roadstead of Sweaborg, to await there the expected attack from the enemy. In the interval the Grand Duke, the General-Admiral of the fleet, had arrived on board pilot steamer *Glökön* to inspect the fleet. The enemy, however, remained in the neighborhood of [illegible]rähara, in expectation of being attacked themselves by the defending force from Sweaborg. At 4:30 p. m. the second division joined the first, and the whole steamed towards Sweaborg. The defending squadron weighed and stood out to attack, but darkness coming on, they returned to the roadstead. The Fiörd flotilla had assembled in the morning at Bonfjord, and, having learnt that one of the enemy's turret ships and a transport were lying at anchor off Egskär, it was determined to attack them. Arrived off Glosholm, it was discovered that the ironclad had gone; the transport, the *Krasn aja-Gorka*, however, was captured by the *Opritschnik*. At 7 p. m. the gunboat *Grosjaschtschi*, with the umpires on board, arrived in the roadstead and signaled that the manœuvres were over.

Possible combinations which might well occur in a war with a powerful enemy were kept in mind in drawing up the General Idea of the manœuvres. But although the General Idea and subsequent disposition left nothing more to be wished for, yet the forces placed at the disposal of both sides were far too small to allow them to carry out the parts alloted to them. The very unfavorable weather also was a great obstacle, and rendered the carrying out of an effective blockade not only very difficult, but almost impossible; neither could the strategical plans be fully carried out, so that a general air of indecision was given to the manœuvres. That the blockade should have been carried out as well as it was is a proof of the skill and endurance of the attacking force and that the ships were commanded by capable seamen; and it also proves the seaworthiness of the vessels, for even in the Admiral class the only loss in the gale of the 28th of August was in the six boats of the *Peter Weliki*, and it may also be remarked that all the damage was caused by the weather alone; nothing went wrong with their engines or boilers.

The General Idea of the manœuvres as far as they went was carried out. The defending force was blockaded in such a way that on the day they ought to have broken through it could not be done, as the ships could not be collected for the purpose. The actions that took place were unimportant; on the other hand, the mines which were laid down proved a real protection, and showed that the clever disposition of mine-fields in waters suitable for the purpose would be of the highest importance, and if the enemy were not aware of their presence, or failed to remove them, he would suffer heavily. Although in this case the attacking force lost several ships by being blown up, yet their loss had no real influence on the course of the operations, as, in consequence of the small number of vessels employed, ships were considered out of action for twelve hours only, and all the less, as the defending commander only learnt the decision of the umpire too late to allow him to utilize his temporary advantage for breaking out of Sweaborg.

The ships were navigated skillfully, considering the difficult nature of the waters in which the field of operations lay. There were only three or four prizes taken, and these were made by ships of the defending squadron.

The Grand Duke Alexis, the General-Admiral of the fleet, issued a memorandum at the end of the manœuvres, expressing his satisfaction with the efforts of the officers and men, and conveying to the flag officers, commanding officers, officers, and men his appreciation of the skill and zeal displayed by them. He specially calls attention to the skilful and bold handling of the *Opritschnik* by her captain, when, her cables having parted in the height of a gale during the night, he took the ship out into the open sea, using his electric search light to find the channel through the breakers. This praise seems to have been well deserved.

NOTE.—A reference to the chart will show that along the northern coast, from Hangö up to Kronstadt, a succession of reefs, islands, etc., and fiörds run the whole way, with deep-water channels between them and the mainland; where the word fiörd has been used in this translation it refers to the deep-water channels and anchorages within the barrier and islands; there being no English word which exactly expresses the word used in the original German for this particular coast formation.

VI.

THE ARMOR QUESTION IN 1891.

By Lieut. W. H. H. SOUTHERLAND, U. S. Navy.

The development of armor has been principally induced by a continued increase in the power of guns and in the quality of projectiles, and can now be traced by the results of practical experiments.

The history and value of such experiments up to 1887 have been so thoroughly and ably treated in the well-known publications of E. W. Very, late of the U. S. Navy, and C. Orde Brown, late of the British Royal Artillery, that it would be a work of supererogation to take up the subject prior to that time. The conditions of armor trials during the past four years, however, have varied so much from preceding ones, and the results obtained have been so definite, that, of necessity, the entire subject must now be treated in a somewhat different manner and the outcome of previous trials set aside as not pertinent to the present issue.

To the physical characteristics of armor plates, as determined by chemical analysis and mechanical tests, we will not refer, but will simply describe and discuss the results obtained in the more important ballistical tests, upon which depend the acceptance or rejection of armor for the protection of war vessels.

Prior to 1887 it was but rarely that the projectile energy was entirely expended in making a clean hole through either compound or steel plates, the results usually obtained being a fractured plate and broken projectile. In consequence—except in competitive trials of different plates of the same dimensions under exactly similar circumstances—all calculations or comparisons were too unreliable to be of value, the outcome being to leave the question of the relative merits of compound and steel armor an open one.

Since 1887, however, these conditions have materially changed. Such have been the improvements in the quality of metal and in the processes of manufacture that it has not infrequently occurred that the projectile has succeeded in making a clean hole without accompanying cracks.

This has been particularly noticeable in late armor trials where light a. p. projectiles with high velocities, which tend to the production of punching effects only, have been employed.

However, this improvement alone would not suffice to give an exact method of comparing the work done on one plate with that done on others unless the work done on the projectile in each case was the same.

But the improvement in the quality and in the manufacture of projectiles has been relatively much greater than in that of plates, and a. p. projectiles are now produced which, so far as compound and steel plates are concerned, can, from their perfection of quality, toughness, and temper, be fairly denominated as unbreakable and undeformable.

As soon as such projectiles were obtained we arrived at a fairly approximate method of comparing, under certain fixed conditions, the resisting powers of different plates to penetration, which method may be illustrated as follows:

The energy required to just send a projectile completely through a wrought-iron plate of a given thickness, without either breaking or deforming the projectile or fracturing the plate, can be computed from one of several well known formulæ, the one we will use being that of de Marre, $pv^2 = a^{1.5} \times \overline{1280}^2 \times e^{1.4}$, which we prefer as being more accurate for projectiles of comparatively small diameter having high striking velocities.

For the sake of comparison let us call this energy, for a certain thickness of wrought-iron plate, 1. Now let us suppose that the energy necessary to cause a projectile of the same calibre to just perforate a compound or steel plate of the same thickness, without either breaking or deforming the projectile or fracturing the plate, to be 1.30, or 30 per cent. greater than that required with the wrought-iron plate. We may then, using the work on a wrought-iron plate of the same thickness as a standard, call the compound or steel plate one of 30 per cent. greater resisting power to penetration.

With each plate discussed we will compute the actual striking energy and then compare it with that necessary to just cause perforation of a wrought-iron plate of the same thickness. This we will do in order to demonstrate the severity of the test to which each plate is subjected; and where the circumstances of work done on both plate and projectile are such as to render it possible, to compare the relative resisting powers of different plates to penetration. It must be borne in mind, however, that to make this method of value in comparing the results on different plates, the plates considered must not be cracked and the projectiles used must remain unbroken and practically undeformed, for otherwise any exact comparison is difficult if not impossible.

In general, however, the value of this method is questionable. In order to show at a glance the severity of the test to which a plate is subjected its use is advocated, but to give a correct idea of the relative resisting powers of compound and steel plates it can not always be relied upon. To demonstrate this we will suppose that two plates, one compound and one steel, each 10½ inches thick, are attacked by 6-inch a. p. projectiles with an energy 25 per cent. greater than that necessary to just perforate a wrought-iron plate of the same thickness, and that each plate is penetrated to the same depth—say 10¼ inches—without being cracked. By this method, then, these plates would be considered to have equal resisting powers. But we know from the results of many trials that the slightly greater energy necessary to overcome the resistance of this compound plate and cause complete perforation would result in only causing a few inches additional penetration in the steel plate, and would not tax it to the limit of its resisting power.

It will be noticed that in all cases armor trials are conducted under conditions exceedingly unfavorable to the plate, more so than would probably ever occur in actual warfare. The gun has every advantage—a steady platform and a normal impact at a short range on an immovable target, so rigidly braced as to receive the full effect of the energy stored up in the projectile. These conditions can not be expected at sea, in consequence of which we assume that our penetration tables for different guns are not to be relied upon to give the correct amount of penetration in well-backed ships' armor, which, in most cases of impact, will be struck at angles not only unfavorable to tabulated penetrations, but also to the holding together of the projectiles.

From the varying conditions of the trials which will be detailed and discussed we consider that a good idea of the armor question at the present time will be best imparted by treating the subject under the following heads:

(I) The development of compound armor plates as shown by details of the most noted trials of late years.

(II) The trials of English steel armor plates in 1888.

(III) The development of Schneider steel armor plates as shown by details of the most noted trials of late years.

(IV) The trial of a Cammell compound armor plate representing the armor of the Argentine coast defense vessel *Independencia.*

(V) A comparison of English compound, Vicker's steel, Schneider's steel, and Schneider's nickel-steel armor plates from the results obtained in the recent competitive tests at Ochta and Annapolis.

(VI) The first trial of a nickel-steel armor plate.

(VII) The armor best adapted to naval use.

The firing trials herein detailed and discussed are only those of which we believe the data given to be authentic. A number of other trials have been referred to in the public prints, which will not be reproduced here because we have been unable to obtain reliable authority for the details given.

I.

THE DEVELOPMENT OF COMPOUND ARMOR PLATES AS SHOWN BY DETAILS OF THE MOST NOTED TRIALS OF LATE YEARS.

Of the compound-armor plate trials, we have been able to obtain complete authentic details of but two trials of Brown plates—one in the Nettle competitive tests of 1888, and the other in the later tests at Helder. The results with the former were so inferior to those with a competing Cammell plate that we do not deem a résumé essential. Partial details of trials of two additional Brown plates have been obtained and will be referred to.

We will describe these trials in chronological order and then compare the results.

TRIAL NO. 1.—*Test of a Cammell compound plate* (*Nettle experiments*) (See Plate I.)

Date of trial: March 24, 1888.

Details of plate: 8 feet by 6 feet by 10½ inches thick, secured by 8 bolts to an oak backing 4½ feet thick. Weight of plate, about 9.2 tons.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge, E. X. E. powder	pounds	48
Projectiles, Holtzer a. p. shell, 17⅝ inches long	do	100
Projectiles, Palliser chilled iron shell	do	98
Striking energy of Holtzer a. p. projectile	f. t.	2,723
Striking energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		1.35
Range	feet	30

Firing details. (See Plate I.)

First shot (Holtzer a. p. projectile).—The projectile penetrated 11⅝ inches and remained sticking in plate with its body much split up. Four fine surface cracks radiating from hole. The back bulge projected 1.8 inches and was 17 inches in diameter.

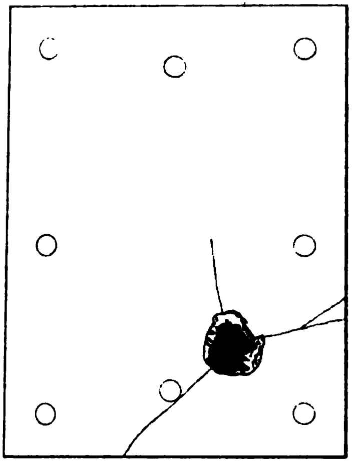
Second shot (Holtzer a. p. projectile).—The projectile penetrated 12⅛ inches and remained sticking in plate with its body much split up. Shot inclined to the left about 10 degrees. Six surface cracks were developed radiating from shot hole. The back bulge was 18 inches in diameter and projected 2.3 inches.

Third and fourth shots (Palliser chilled iron projectiles).—Projectiles broke up against plate, the point of the latter remaining in plate. Former cracks extended, and a few new surface cracks developed. Part of body of No. 1 shot fell out. Slight bulging at back of plate.

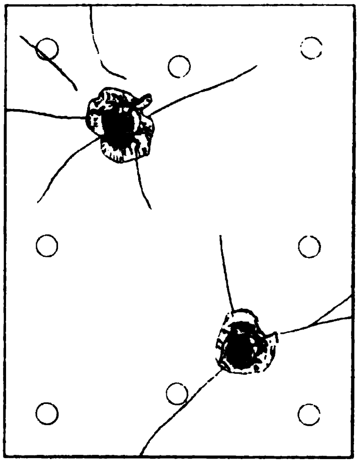
Fifth shot (Holtzer a. p. projectile).—The projectile penetrated 11¼ inches and remained sticking in plate with its body much split up. Five surface cracks and considerable scaling off of steel face around shot hole. The back bulge was 18 inches in diameter and projected 2.1 inches.

This plate was tested in competition with a number of English made compound and steel plates during the Nettle experiments of 1888, and not only proved superior to all its competitors, but gave better results than had ever before been obtained from a compound plate under simi-

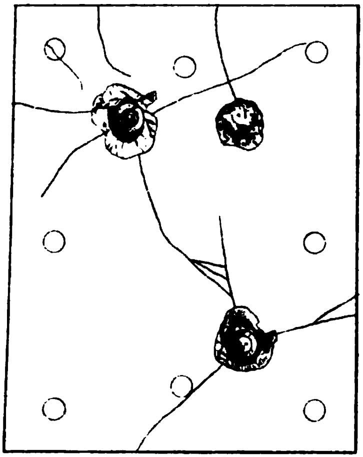
TRIAL NO. I CAMMELL COMPOUND PLATE PLATE I.



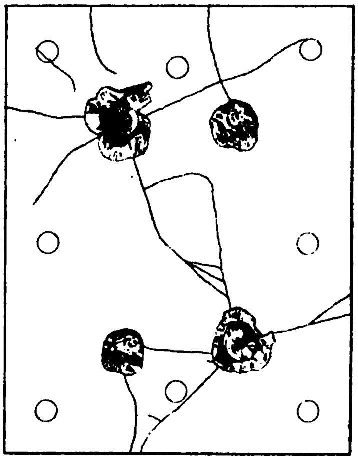
HOLTZER a.p. PROJECTILE



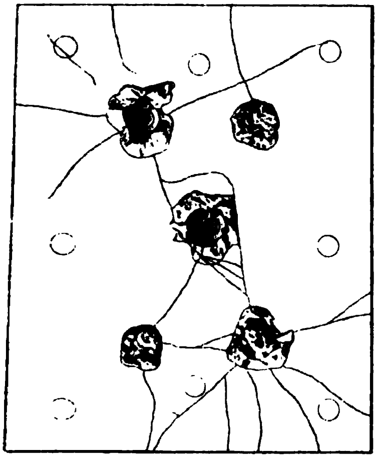
HOLTZER a.p. PROJECTILE



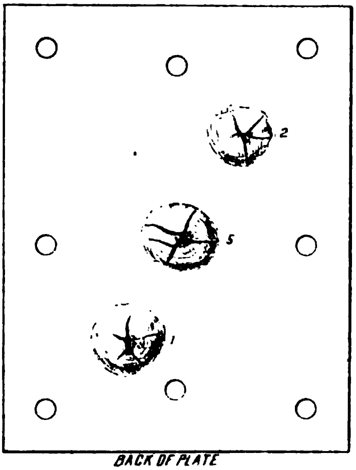
PALLISER CHILLED PROJECTILE



PALLISER CHILLED PROJECTILE



HOLTZER a.p. PROJECTILE



BACK OF PLATE

lar conditions. The projectile energy was a little less than the resisting power of the plate, but, as some work was expended in breaking the projectiles, we can not say that the resisting power of the plate was more than 35 per cent. greater than that of a wrought-iron plate of the same thickness.

The most important point brought out in regard to this plate was the decided uniformity of the metal of which it was composed, this being evidenced by the nearly equal penetrations of the three Holtzer a. p. projectiles, and the similar amount of work done on each, they all breaking in about the same manner.

The brittle Palliser projectiles, as was to have been expected, broke up against the hard steel face with but slight penetrations, not exceeding 2 inches, and gave no index of the qualities of the plate.

TRIAL NO. 2.—*Competitive test of compound armor plates off Helder, North Holland.* (See Plate II.)

Date of trial: November, 1889.

Details of plates: Four plates, all of the same dimensions, 9 feet long, 6 feet 11.06 inches wide, and 11.02 inches thick, and each weighing about 12.4 tons.

Three of the plates were manufactured on the Wilson system by Cammell, St. Chamond, and Marrel, respectively, and the fourth on the Ellis system by Brown. The Brown and Cammell plates were made in England, the remaining two in France.

Backing: One layer of 12-inch horizontal teak balks; another of 12-inch vertical teak balks; and two three-fourth-inch steel plates at the back, all held up by heavy timber struts. The plates were set up on the deck of a large barge in the following order: St. Chamond, Marrel, Brown, Cammell.

Ballistical details.

[Gun, Krupp, 28 centimetres (11.02-inch), 27-ton B. L. R.]

Forged steel projectile	pounds..	556
Striking velocity	f. s..	1,344
Striking energy	f. t..	6,962
Range	feet..	262.4
Energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		1.31

Firing details. (See Plate II.)

First shot (St. Chamond plate).—Projectile perforated plate and backing, breaking the plate into three large pieces and throwing a large number of fragments to some distance.

Second shot (Cammell plate).—Projectile perforated plate and backing, and developed seven surface cracks. Projectile supposed to have been broken.

Third shot (Marrel plate).—Projectile perforated plate and backing, and fell into the sea several hundred yards to the rear of plate. Plate broken into three pieces and a number of serious cracks developed. Much scaling about shot hole.

Fourth shot (Brown plate).—Deep penetration of projectile, but not perforation. Three surface cracks and a number of light concentric cracks. Projectile broke up leaving its head in plate.

Fifth shot (Cammell plate).—Projectile perforated plate and backing, detaching a strip of the hard steel face about 6 inches wide between the two shot holes and exposing the soft back. One through crack to middle of right-hand edge. Several new surface cracks. Previous cracks somewhat extended.

Sixth shot (Brown plate).—Projectile failed to perforate, but broke up, leaving its head in the plate and dislodging a part of the head left in at the first shot. A through crack running to each side and several surface cracks. Previous cracks deepened and extended. Considerable scaling about shot hole.

Seventh shot (Brown plate).—Projectile perforated plate and backing, splitting the plate into two parts, breaking off a large fragment, and scaling off considerable of the hard steel face from its wrought-iron back.

Eighth shot (Cammell plate).—Projectile perforated plate and backing. Many new surface cracks, and old cracks deepened and extended. Hard steel face separated from wrought-iron back over a considerable space and thrown off.

Ninth shot (Marrel plate).—Projectile perforated plate and backing. A number of wide through cracks and several surface cracks. Much scaling off of hard steel face from wrought-iron back.

Tenth shot (St. Chamond plate).—Projectile perforated plate and backing. Much of the hard steel face scaled off from wrought-iron back. Wide through cracks from first shot hole to bottom of plate. Upper broken piece thrown up on top of plate. Plate badly wrecked.

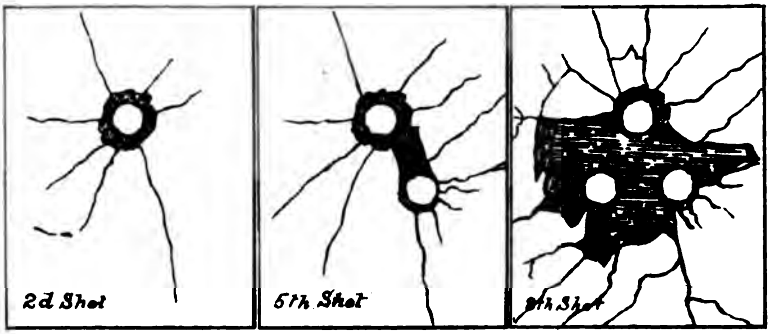
This test was a severe one for any plate of the thickness given, and it is to be regretted that it was impossible to determine the effect on the projectiles. The French plates were so badly treated that they were entirely out of the contest after the first shot at each. The Cammell plate was no match for the projectiles; they perforated it with ease. As is very common with Cammell plates much of the hard steel face separated from the soft back, thus indicating imperfect welding.

The Brown plate behaved extremely well, better than any of its make previously tried. It stopped the two first projectiles, but with a result not common when a. p. projectiles are used against compound plates, for white splashes were developed about the shot holes very similar to those appearing on compound plates when attacked by Palliser projectiles. This could be ascribed to faulty projectiles, but it is believed that the projectiles used were of Krupp manufacture, the reputation of which is so good that we must give the plate the benefit of the doubt, and so consider that it behaved excellently. The separation of the hard steel face was noticeable at the third shot, but not to the same extent as with the Cammell plate.

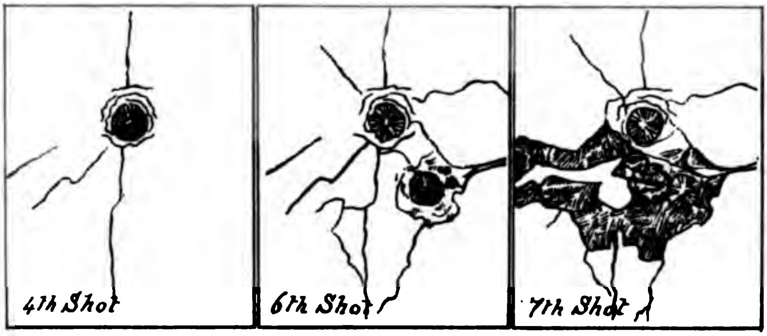
This trial is valuable in demonstrating the shattering effects of large

TRIAL NO. 2 PLATE II.

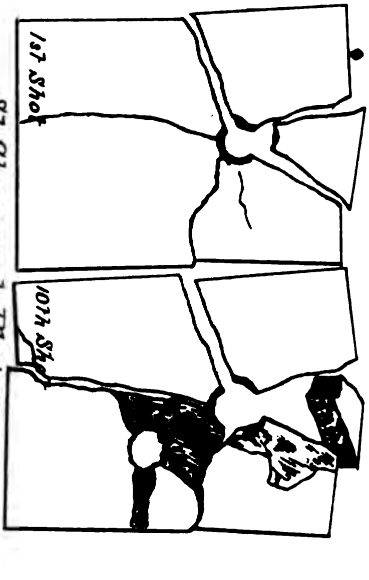
HELDER COMPETITIVE TRIALS



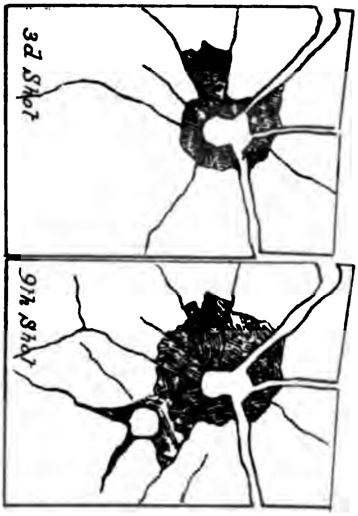
Cammell Plates



Brown Plates



St Chamond Plates



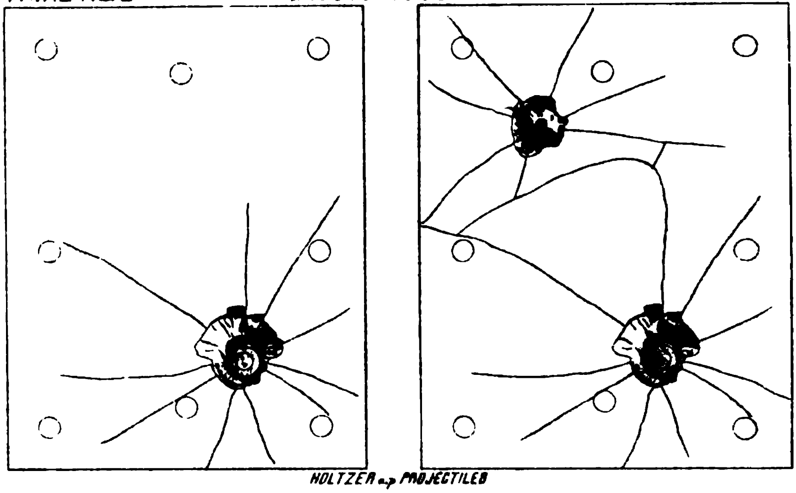
Marrel Plates

TRIAL NO.3

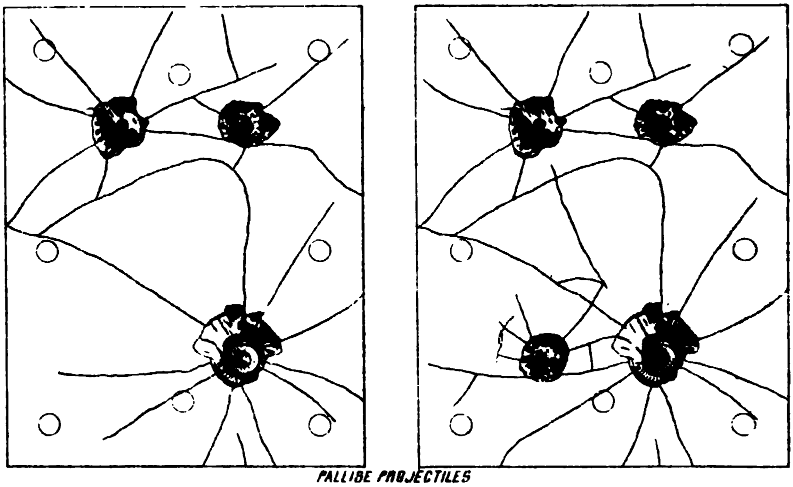
CAMMELL COMPOUND PLATE

FOR "HOOD" AND "ROYAL SOVEREIGN"

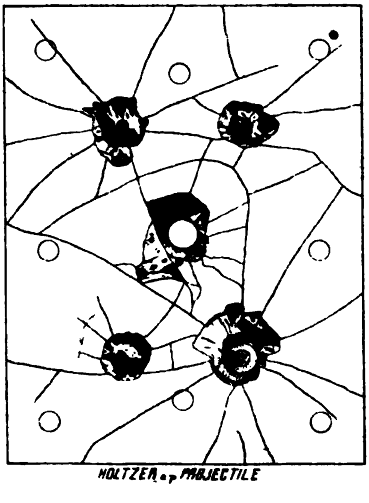
PLATE III.



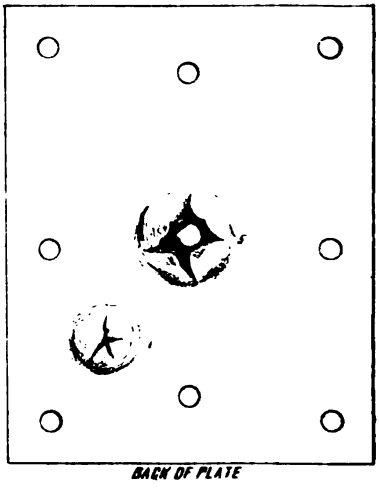
HOLTZER a.p PROJECTILES



PALLISE PROJECTILES



HOLTZER a.p PROJECTILE



BACK OF PLATE

calibre projectiles having low velocities. All the compound plates in this trial were badly through-cracked, and it will be well to remember that in actual warfare we must expect vessels to be attacked by projectiles of this and larger calibres.

The comparative energy of 1.31 herein indicated does not give an adequate idea of the severity of this test, the formula used being for small calibre projectiles having high velocities.

TRIAL NO. 3.—*Test of a Cammell compound plate representing the barbette and turret armor for the English battle ships Hood and Royal Sovereign.* (See Plate III.)

Date of trial: May 1, 1890.

Details of plate: 8 feet long by 6 feet wide and 10½ inches thick. Secured to an oak backing 4½ feet thick by 8 bolts. Weight, about 9.2 tons. The plate selected for test, when finished, would have been 17 feet 6 inches, by 6 feet 6 inches, by 17 inches, but when in its heated state it was broken, given additional heat, and rolled down to 10½ inches.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge of E. X. E. powder	pounds..	48
Projectiles for first, second, and fifth shots, Holtzer armor-piercing	do....	100
Projectiles for third and fourth shots, Palliser chilled iron	do....	98
Striking energy of Holtzer a. p. projectile	f. t..	2,723
Energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		1.35
Range	feet..	30

Firing details. (See Plate III.)

First shot (Holtzer a. p. projectile).—Point of impact, 2 feet from bottom and 2 feet from right edge of plate. The projectile penetrated and was badly cracked, but remained in the plate with its base protruding 6 inches. Parts of steel face around hole scaled off. Ten fine radial cracks in steel face. Back of plate bulged out 2½ inches and to a diameter of 20 inches.

Second shot (Holtzer a. p. projectile).—Point of impact at corresponding point at upper left-hand corner. Projectile did not get its point through plate, but broke up, its point remaining in plate. Parts of steel face scaled off around shot hole. Seven fine radial cracks in steel face, two of them running into one crack developed by the first shot. Back of plate bulged out nearly 1½ inches, but not cracked.

Third and fourth shots (Palliser chilled-iron projectiles).—Points of impact at corresponding points on upper right-hand and lower left-hand corners. Each shot broke up after but a small penetration and left its head in the plate. A number of fine cracks developed in the steel face. Back bulged but slightly.

Fifth shot (Holtzer a. p. projectile).—Point of impact at middle of plate. Complete perforation. Projectile penetrated deeply into backing. Considerable scaling of steel face around shot hole. High bulge on back of plate.

In this test the results were much inferior to those obtained in Trial No. 1. The penetration of the first Holtzer was a litttle less than there obtained, but the effect on the plate was greater. The penetration of the second Holtzer was still less, due either to better quality of metal about the point of impact or to the projectile being defective, while the last Holtzer overcame the resistance of the plate with ease. The plate showed a decided lack of homogeneity.

One of the worst features in English armor tests is illustrated by this plate, which was supposed to represent the barbettes of the *Hood* and *Royal Sovereign.* The actual dimensions of the plates for these barbettes are 17½ feet by 6½ feet by 17 inches, but this proof plate was cut down to the Nettle standard of 8 feet by 6 feet and rolled down to a thickness of 10½ inches. There is a limit to the thickness from which a Cammell plate can be rolled down, and, as this rolling is a most important factor in the process of manufacture, it seems only reasonable to suppose that the 10½-inch plate, opposed by a 6-inch B. L. R., would prove much superior to a similarly manufactured plate rolled down to 17 inches only, opposed by a corresponding calibre of gun. Consequently, we feel justified in concluding that this 10½-inch plate did not properly represent the barbettes referred to, and hence, that this trial as a test of these barbettes, was of no practical value.

TRIAL NO. 4.—*Test of a Cammell compound plate representing the belt armor for the Spanish armored cruiser Infanta Maria Teresa.* (See Plate IV.)

Date of trial: September 5, 1890.

Details of plate: 8 feet long by 6 feet wide by 10¼ inches thick, secured to an oak backing 4½ feet thick by eight 4-inch bolts. Weight, about 9.2 tons. Steel face, inches thick.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge of E. X. E. powder	pounds..	[illegible]
Projectiles for first, second, and fifth shots, Holtzer	do...	[illegible]
Projectiles for third and fourth shots, Palliser	do...	[illegible]
Striking energy of Holtzer armor-piercing projectiles	f. t..	[illegible]
Energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		[illegible]
Range	feet..	[illegible]

Firing details. (See Plate IV.)

First shot (Holtzer a. p. projectile).—Point of impact, 2 feet from bottom and feet from right edge of plate. The projectile penetrated and remained in plate with its base projecting 5 inches. The usual scaling off of steel face around hole. Nine superficial cracks, No. 1 afterwards showing through the steel face. Back of plate bulged out 2¾ inches and to a diameter of about 21 inches, with a crack of three-fourths inch, from which eight slight radial cracks spread out to but a short distance. The projectile was much set up and had its body cracked.

Second shot (Holtzer a. p. projectile).—Point of impact at corresponding upper left-hand corner. The projectile perforated plate and penetrated 24 inches into backing. Seven cracks, one apparently through steel face. Considerable scaling around shot hole. Broken part of back bulged out 6¼ inches. Projectile not recovered.

Third and fourth shots (Palliser chilled-iron projectiles).—Points of impact at corresponding points at upper right-hand and lower left-hand corners. Projectiles broke up, points penetrating and remaining in plate. Back bulged out four-fifths of an inch, and to a diameter of about 12 inches.

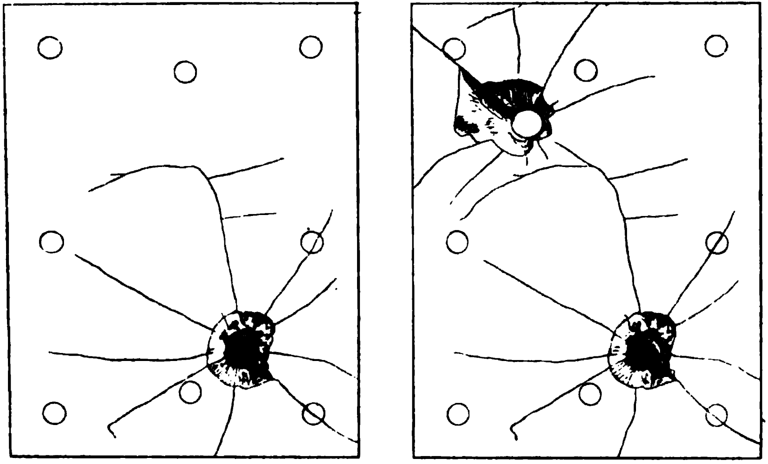
Fifth shot (Holtzer a. p. projectile).—Point of impact at centre of face. Projectile perforated plate, penetrating some distance, more than 22 inches, into backing, and was not recovered. Deep scaling around shot-hole. Former cracks deepened, and several others developed. Back of plate bulged out to a distance of 7 inches.

TRIAL NO 4

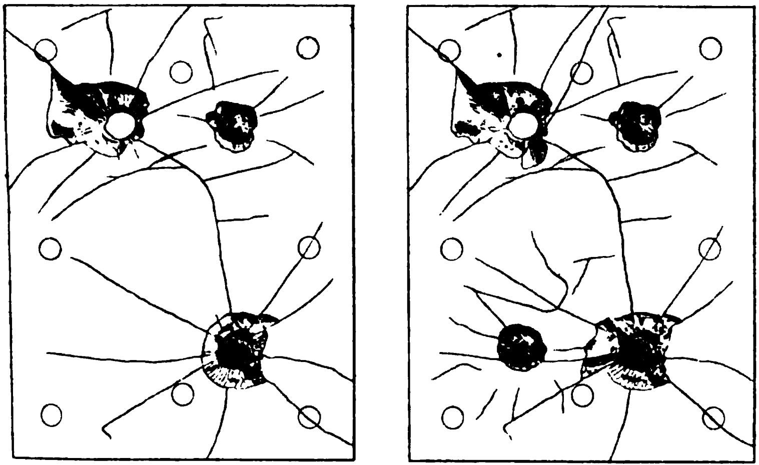
CAMMELL COMPOUND PLATE

FOR "INFANTA MARIA THERESA"

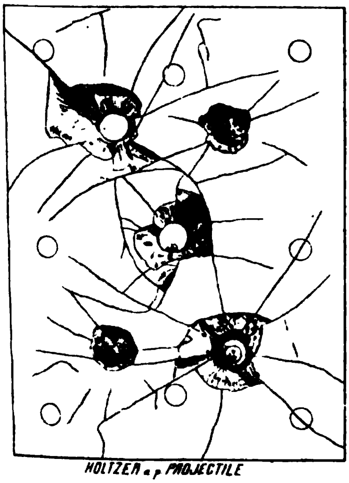
PLATE IV.



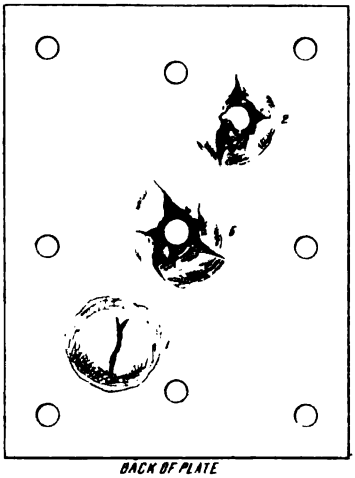
HOLTZER a.p. PROJECTILES



PALLISER PROJECTILES



HOLTZER a.p. PROJECTILE



BACK OF PLATE

This plate was greatly outmatched by the projectiles, showing much less resisting power than either plate in trials Nos. 1 and 3. Not only were the penetrations much greater, but the hard steel face suffered much more. From the effect on the first Holtzer it would seem that the projectile was not of good quality.

It is not at all surprising that the Spanish naval authorities were not satisfied with this test and refused to accept it as conclusive. In connection with this action of the Spanish authorities, it may be of interest to state that within less than a year prior to this trial two Brown 10½-inch compound plates were tested under exactly similar conditions, but with worse results, and were accepted by the English Admiralty. The results with the three Holtzer a. p. projectiles used against each were as follows:

First plate.—Tested in November, 1889.

First Holtzer perforated, point of projectile going in 3 feet 10¾ inches from face of plate.

Second Holtzer penetrated 12 inches.

Third Holtzer (fifth shot) perforated, point of projectile going in 3 feet from face of plate.

Second plate.—Tested in June, 1890.

First Holtzer penetrated 11¼ inches.

Second Holtzer perforated, point of projectile going in 3 feet 9¾ inches.

Third Holtzer (fifth shot) perforated plate and backing, and struck 4-inch iron bulkhead 52 feet from backing.

The preceding trials are interesting in many particulars, but principally as evidencing that progress in the improvement of Cammell compound steel-faced armor plates seems to have reached its limit.

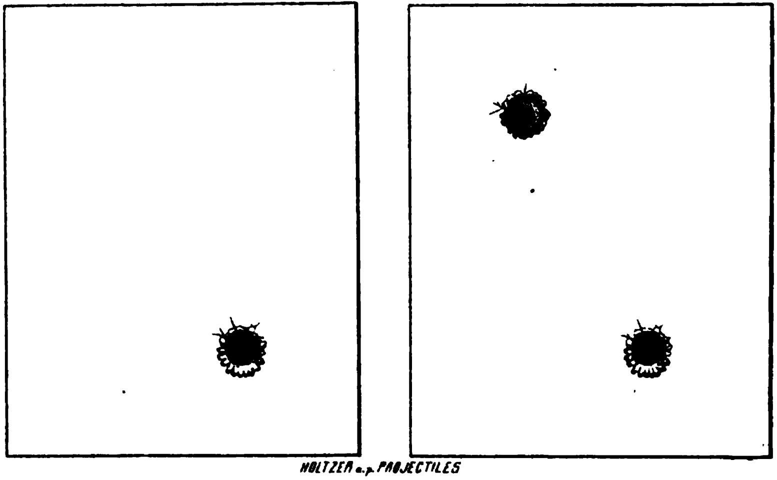
The conditions in all but Trial No. 2 were identical, and it is presumed that the plates were constructed in the order in which the trials took place. In each case the striking energy was only 35 per cent. greater than that necessary to just perforate a wrought-iron plate of the same thickness.

In comparing the results of the trials of these 10½-inch plates, two important points must be taken into consideration—the homogeneity of the plates and the quality of the projectiles used.

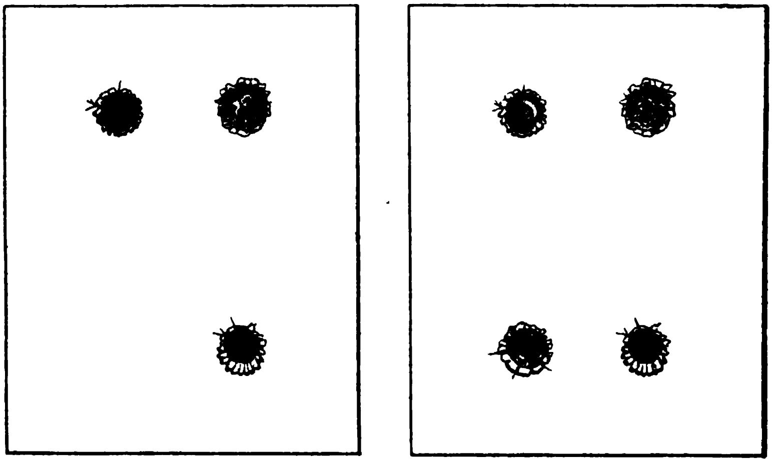
Compound plates depend for their resistance on the hardness of the steel face and the perfection of its weld to the wrought-iron back, this soft back giving but little additional power of resistance. The lack of uniformity in results obtained under similar conditions, and the frequent scaling off of the hard steel faces in these and many other trials are sure indications that the welding can not always be depended upon.

At first sight it would appear that these three 10½-inch plates have deteriorated in quality in the order in which they have been taken, but when we consider that the manufacturers are the largest and most experienced steel-faced compound plate makers in the world, it does not seem probable that they would produce plates in 1890 inferior in resisting qualities to those made in 1888 or earlier. It is more likely that

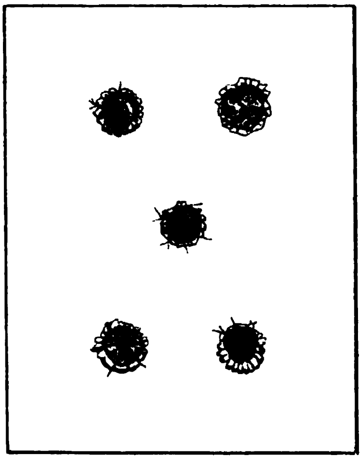
TRIAL NO 5 CAMMELL SOLID STEEL PLATE PLATE V.



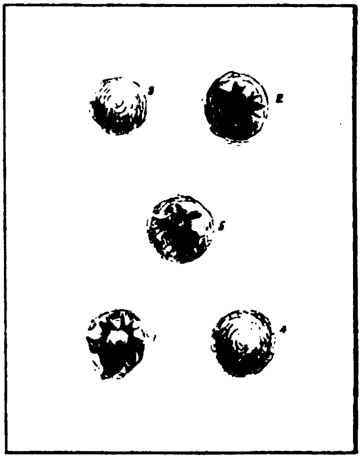
HOLTZER a.p. PROJECTILES



PALLISER PROJECTILES



HOLTZER a.p. PROJECTILE



BACK OF PLATE

II.

THE TRIAL OF ENGLISH STEEL ARMOR PLATES IN 1888.

Of a number of English-made steel plates which were tested during the Nettle competitive experiments of 1883, but two—one made by Vickers and the other by Cammell—gave results at all comparable with those obtained from the competing Cammell compound plate of Trial No. 1.

These trials will be detailed here, partly as marking the beginning of a steel armor-making era in England, and partly to be used in comparison with English-made steel plates of later manufacture.

TRIAL No. 5.—*Test of a Cammell solid steel armor plate.* (*Nettle experiments.*) (See Plate v.)

Date of trial: May 19, 1888.

Details of plate: 8 feet by 6 feet by 10½ inches, secured by 8 bolts to an oak backing 4½ feet thick. Weight of plate about 9.4 tons.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge: E. X. E. powder.......pounds..	48
Projectiles:	
Holtzer a. p. shell ....do....	100
Palliser chilled-iron shell.......do....	98
Striking energy of Holtzer a. p. projectile.......f. t..	2,723
Striking energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness.......	1.35
Range ....feet..	30

Firing details. (See Plate v.)

First shot (Holtzer a. p. projectile).—The projectile penetrated 23.3 inches and broke in two, the head remaining in backing and the base in plate. Front bulge, 17 inches in diameter with its fringe projecting 2 inches. Back bulge, 15 inches in diameter, projecting 4¾ inches. No cracks, but a few short radiating fissures in front bulge.

Second shot (Holtzer a. p. projectile).—The projectile penetrated 13.1 inches and remained in plate unbroken. Front bulge, 17 inches in diameter, with its fringe projecting 2 inches. No cracks, but 5 short radiating fissures in front bulge. Back bulge, 14 inches in diameter, projecting 4 inches.

Third and forth shots (Palliser chilled-iron projectiles).—The projectiles broke up, their heads remaining in plate. Penetration not given, but no holes or cracks in back of plate—only well-developed bulges.

Fifth shot (Holtzer a. p. projectile).—Projectile penetrated 16 inches, and remained sticking in plate apparently uninjured. Front bulge, 18 inches in diameter, with its fringe projecting 2 inches. No cracks, but 6 short radiating fissures in front bulge. Back bulge, 14 inches in diameter, projecting 5 inches.

This plate showed, by the difference in the penetrations of the Holtzer projectiles, a decided lack of uniformity in the metal of which it was composed. A very slightly greater energy with the first projectile would have caused perforation. The bulging of the back was very pronounced, as much so as is the case with compound plates. This was particularly noticeable with the Palliser shells, and gives undoubted evidence of the great softness of the metal of the plate. A good wrought-iron plate would have bulged but little more. In an examination of the backs of many of the earliest-made Schneider steel plates no such excessive bulging is found. Had this plate been secured to a ship's side it is probable that the framing behind it would have been materially injured.

TRIAL No. 6.—*Test of Vickers cast-steel armor plate (Nettle experiments).* (See Plate VI.)

Date of trial: September 6, 1888.

Details of plate: 8 feet by 6 feet by 10¼ inches, secured by 8 bolts to an oak backing 4¼ feet thick. Weight of plate, about 9.4 tons.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge: E. X. E. powder	pounds	48
Projectiles:		
Holtzer armor-piercing shell	do	100
Palliser chilled-iron shell	do	98
Striking energy of Holtzer a. p. projectiles	f. t.	2,723
Striking energy as compared with that necessary to just perforate a wrought iron plate of the same thickness		1.35
Range	feet	30

Firing details. (See Plate VI.)

First shot (Holtzer a. p. shell).—The projectile penetrated 13¼ inches and rebounded 22 feet uninjured. No cracks. A few short radial fissures in front bulge. Fringe projecting 2 inches. Back bulge 12 inches in diameter, projecting 3.5 inches.

Second shot (Holtzer a. p. shell).—The projectile penetrated 13 inches and rebounded slightly distorted and set up. A radial through crack was developed extending to upper edge of plate. Fringe projecting 2.5 inches. Back of plate bulged and cracked through bulge. Back bulge 12 inches in diameter, projecting 1.8 inches.

Third shot (Palliser shell).—Projectile penetrated about one-third its length and broke up, leaving its head in the hole. Two cracks produced, apparently not through plate. Back of plate bulged out 3 inches.

Fourth shot (Palliser shell).—About the same penetration as No. 3 shot. No cracks. Head of projectile remained in hole. Back of plate bulged out 0.85 inch.

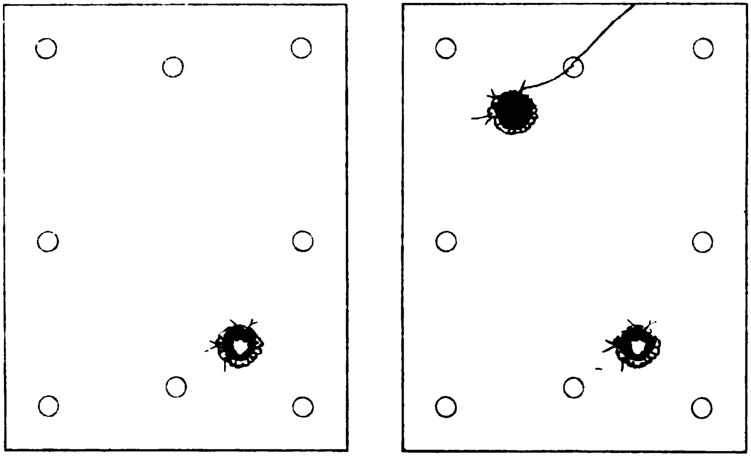
Fifth shot (Holtzer a. p. shell).—Projectile penetrated 13 inches and then rebounded, slightly distorted and set up. Fringe projecting 2 inches. One radial surface crack developed running to No. 2 shot hole. The crack running from the right side of No. 3 shot hole extended through the plate from the effects of the two last shots. Back bulge 12 inches in diameter, projecting 2.5 inches.

A second Vickers plate was tried in February, 1889, but did not give quite as good results as the one above.

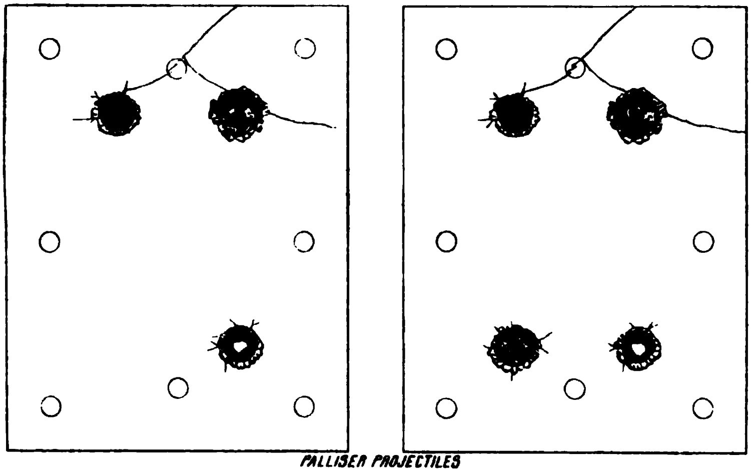
This plate gave excellent results when we consider that it was the first thick plate produced by its maker.

The equal penetrations and the very similar effects on the a. p. projectiles gave evidence of great homogeneity of plate.

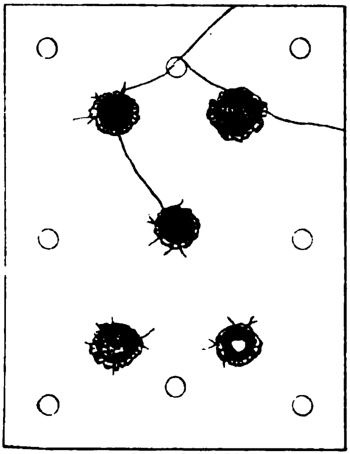
TRIAL NO. 6 VICKERS CAST STEEL PLATE PLATE VI.



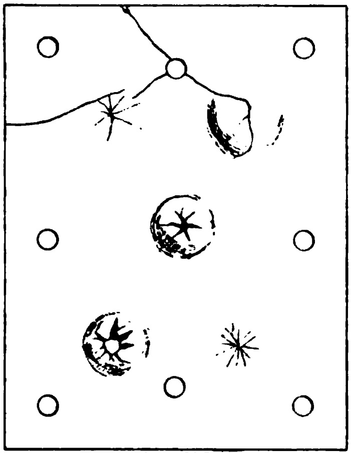
HOLTZER a. p. PROJECTILES



PALLISER PROJECTILES



HOLTZER a. p. PROJECTILE .



BACK OF PLATE

The elasticity of the metal was well exemplified by the rebounding of the projectiles, and its comparative softness by the effect on the back of the plate. It was the only plate tested during the Nettle experiments of 1888 which compared favorably with the Cammell compound plate of Trial No. 1.

The general results were such as to lead to the belief that it was very similar in composition to the Duilio steel plates (Schneider) tested in 1876.

These two can not be taken as representative of modern solid steel plates, having been produced by manufacturers who had had no previous experience with solid steel plates of so great a thickness.

The Vickers plate gave such satisfactory results for a first effort that its makers received a large order from the English Government for ship's armor.

Both plates were comparatively soft, the Cammell much more so than the Vickers, but the latter was more homogeneous and possessed a greater degree of elasticity.

III.

THE DEVELOPMENT OF SCHNEIDER STEEL ARMOR PLATES AS SHOWN BY DETAILS OF THE MOST NOTED TRIALS OF LATE YEARS.

The difference in the methods of conducting trials in the two countries precludes any fair comparison of English compound and French steel plates. Consequently, in detailing the following trials we can do no more than note the development made in Schneider steel plates during the last four years.

The method employed in testing plates in England has been described. That employed in France is radically different and much more satisfactory, the proof plate of a vessel's armor being selected by a Government commission from a number already finished for delivery, and put up for trial in its actual shape, thus exactly representing the armor of the vessel for which it is intended.

Even under these circumstances an approximate comparison with English plates might be made if the conditions of firing were similar, but here again a great difference exists. The English use three a. p. and two chilled projectiles with points of impact as indicated in the preceding trials, while the French use three chilled projectiles only with points of impact as shown in the following trials.

The French projectiles are in better repute than the Palliser, but even if they were of exactly similar quality no comparison of the probable resisting power of the plates under service conditions would be possible. In reports of English armor trials mention is rarely made of the amount of penetration of the Pallisers, but we know that it can not be much, owing to the fact that the projectiles are brittle, such as serve to bring out most clearly the one great advantage of the compound plate—the ability of its hard steel face to resist and destroy projectiles of medium quality. Where the other conditions are exactly similar, penetration depends upon the projectile, in consequence of which variations in its qualities of hardness and toughness count for a great deal in armor tests. A fair comparison is only possible when plates are tried under exactly similar conditions, such as was the case in the Ochta and Annapolis competitive trials of 1890.

TRIAL NO. 7.—*Test of a Schneider steel plate representing hatch plates for the Danish protected cruiser Walkyrie.* (See Plate VII.)

Date of trial: May 23, 1888.

Details of plate: Of an irregular shape, from 4½ to 7½ feet wide by from 4 to 4¾ feet high by 5½ inches thick, and weighing 2.45 tons. It was bolted to a backing of 23.6 inches of wood. The points of impact were at the points of an equilateral triangle having its base horizontal and with each side of a length of 2½ calibres.

Ballistical details.

[Gun, 15-centimetre (5.91-inch), 36 calibre B. L. R.]

Powder charge, B. P	pounds	30.4
Projectile, chilled cast-iron	do	83.8
Striking velocities:		
First shot	f. s.	1,410
Second shot	do	1,392
Third shot	do	1,496
Striking energies:		
First shot	f. t.	1,155
Second shot	do	1,126
Third shot	do	1,300

The corresponding striking energies, as compared with those necessary to just perforate a wrought-iron plate of the same varying thicknesses, were 1.46, 1.42, 1.64.

Firing details. (See Plate VII.)

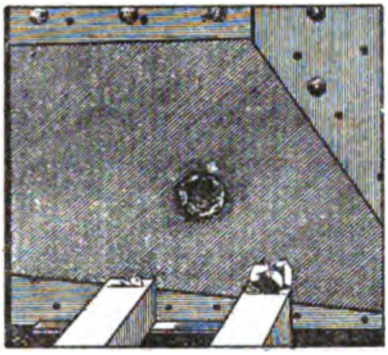
First shot.—Projectile penetrated 3.86 inches, broke up and fell in front of plate; no cracks.

Second shot.—Projectile penetrated 5 inches and broke up; two fine cracks developed; one from second shot hole to lower edge of plate; the other, a very fine one, extending to about 4 inches below first shot hole.

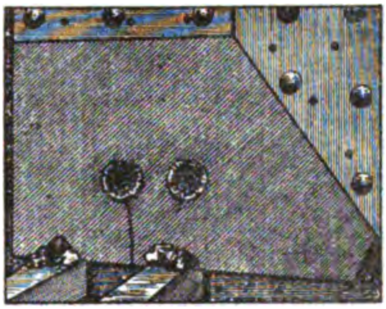
Third shot.—Projectile penetrated 5.6 inches and broke up. The previously made cracks deepened, the longer one apparently through the plate. Several fine surface cracks developed, as shown in figure, and one deep, possibly through, crack extending to left edge of plate. Head of projectile remained in hole.

This hatch plate was a counterpart of one designed for the *Walkyria*. Each of the projectiles being broken in about the same manner and the respective penetrations not being in proportion to the varying projectile energies, are good reasons for the belief that the metal of the plate lacked uniformity. This conclusion applies to the results of all three shots; but with the third, which had the greatest projectile energy, the fact that so little additional penetration was obtained may be accounted for by the supposition that much of the energy was expended in augmenting the previously formed fine cracks.

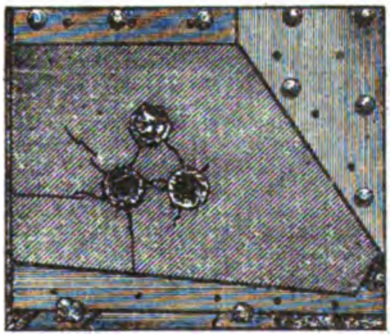
WALKYRIE'S PLATE



FIRST SHOT.



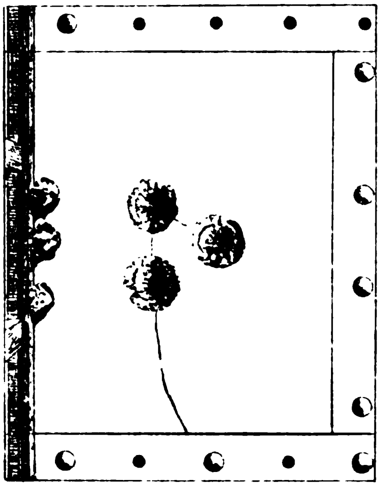
SECOND SHOT.

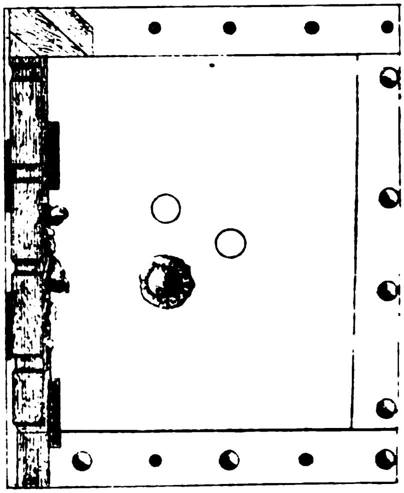


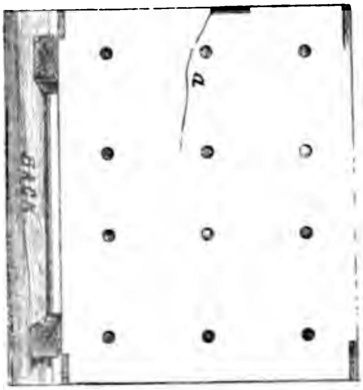
THIRD SHOT.

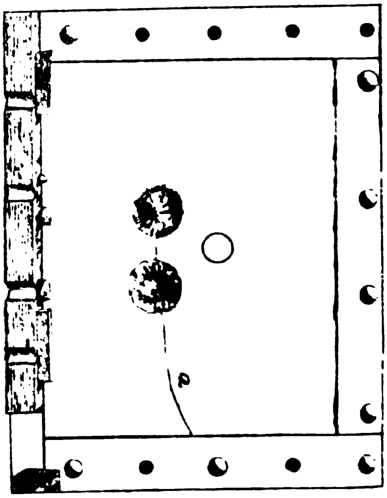
TRIAL NO. 8 PLATE VIII.

GOTA'S PLATE









It is quite evident that the plate would have been matched had a. p. projectiles been used.

TRIAL NO. 8.—*Test of a Schneider steel plate representing the armor of the Swedish coast defense vessel Gota.* (See Plate VIII.)

Date of trial: October 23, 1888.

Details of plate: 6.5 feet wide by 4.8 feet high by 9.6 inches thick, and weighing 5.66 tons. It was bolted to 23.6 inches of backing by 12 bolts. The points of impact were at the points of an equilateral triangle having its base horizontal and with each side of a length of 2¼ calibres.

Ballistical details.

[Gun used, 15-centimetre (5.91-inch), 36 calibre B. L. R.]

Projectile, chilled cast-iron	pounds	99.2
Powder charge, B. P	do	35.5
Striking velocity:		
First shot	f. s.	1,850
Second shot	do.	1,843
Third shot	do.	1,819
Striking energy:		
First shot	f. t.	2,353
Second shot	do.	2,336
Third shot	do.	2,275
Range	feet.	184

The mean striking energy, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, was 1.35.

Firing details. (See Plate VIII.)

First shot.—The projectile penetrated to a depth of 3.84 inches, broke into a number of pieces, and fell in front of the target. No cracks.

Second shot.—The projectile penetrated 3.39 inches and broke up, its head remaining in the hole. A fine surface crack was developed between the two shot holes, and a fairly deep crack from No. 1 shot hole to the right edge of plate.

Third shot.—The projectile penetrated 3.66 inches, broke and fell in front of the plate, the shock of its impact causing the head of the second shot to fall out. A fine surface crack was developed connecting this with the second shot hole. The crack previously developed, *a*, was enlarged to extend through the plate.

This represented, in all its dimensions, a plate designed for the *Gota*. The results were excellent, the similarity in the effects on plate and projectiles clearly demonstrating the homogeneity of the plate.

Nothing more can be said, however, for the plate greatly outmatched the projectiles. From later results with steel plates we are justified in concluding that with similar projectile energies this plate would have also outmatched Holtzer a. p. projectiles of the same calibre.

This was evidently a much better plate than that of the *Walkyrie*, and it is to be regretted that its actual resisting power was not more fully developed by the employment of a striking energy proportionate to that used with the latter.

TRIAL NO. 9.—*Test of a Schneider steel plate representing the side armor of the Chilian battle ship Capitan Prat.* (See Plate IX.)

Date of trial: May 23, 1890.

Details of plate: 18.32 feet wide by 6.76 feet high, and decreasing in thickness from top to bottom. The thickness at the point of impact of each shot was as follows: First shot, 6.3 inches; second shot, 6.28 inches; third shot, 6.99 inches. These were at the points of an equilateral triangle having its base horizontal and with each side of a length of 2¼ calibres. The plate weighed 15.17 tons.

Ballistical details.

[Gun, 16-centimetre (6.49-inch) B. L. R.]

Projectile, chilled cast-iron	pounds	99.2
Striking velocity:		
First shot	f. s.	1,463
Second shot	do.	1,460
Third shot	do.	1,567
Striking energy:		
First shot	f. t.	1,472
Second shot	do.	1,466
Third shot	do.	1,687

The striking energy of the last shot as compared with that necessary to just perforate a wrought-iron plate of the same thickness, 6.99 inches, was 1.39.

Firing details. (See Plate IX.)

But one shot, the first, succeeded in getting its nose through. Three cracks were developed, as shown, the two lower ones going through. The projectiles were all broken in about the same manner.

In this trial the plate behaved excellently; much better than in either of the preceding ones.

The nearly equal penetrations and the similar manner in which each shot was broken indicated uniformity of metal of plate. It is well to note that the backing was comparatively uninjured.

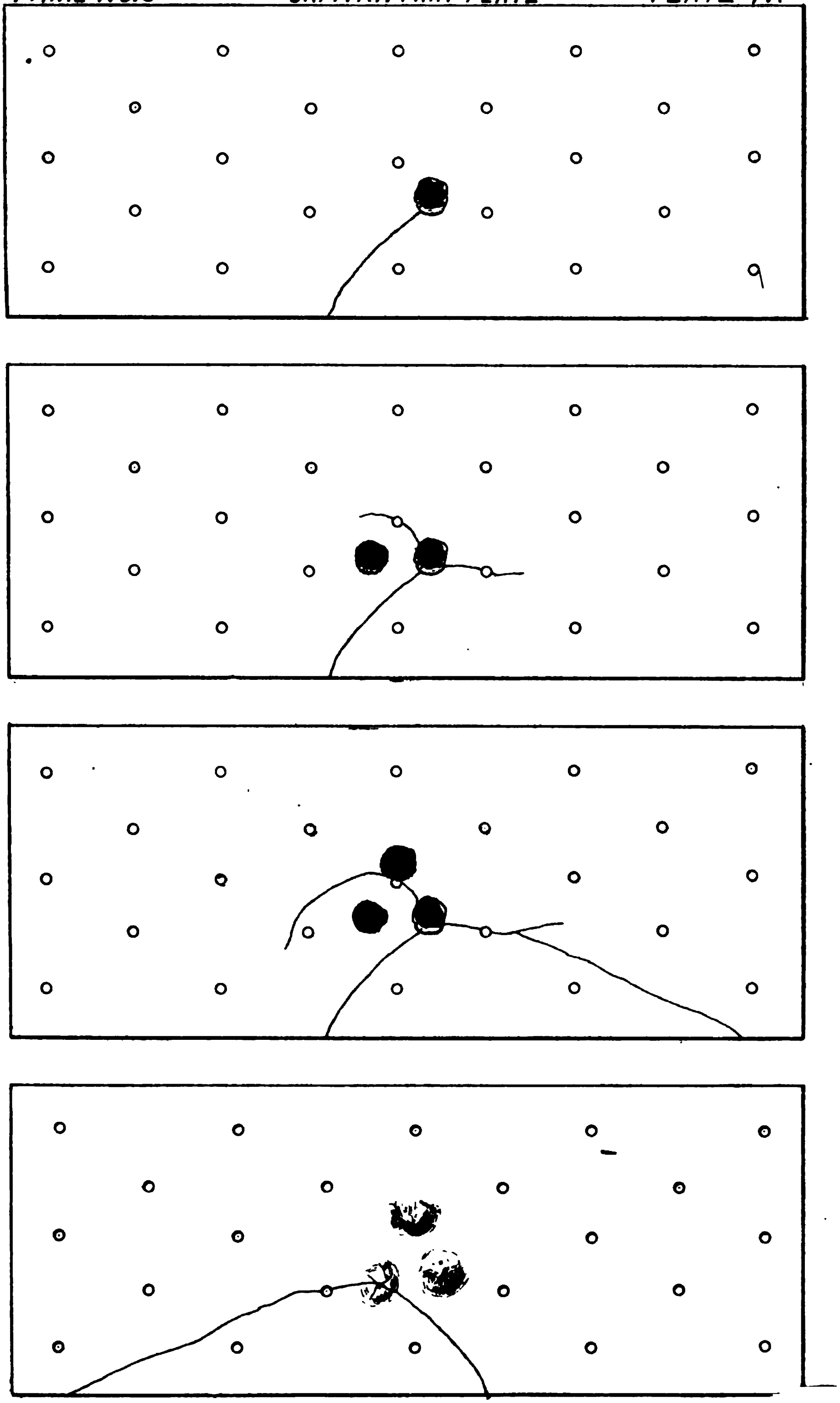
The Gavre Commission gave this plate its highest term of merit—"*tres satisfaisante.*"

TRIAL NO. 10.—*Test of a Schneider steel plate representing the conning towers of the Danish coast defense vessel Tordenskjold and protected cruiser Hekla.* (See Plate X.)

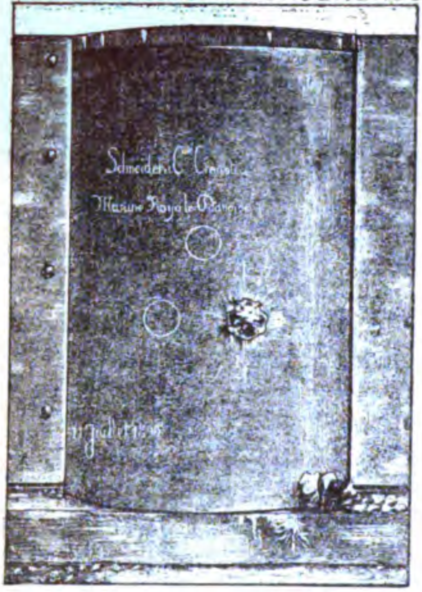
Date of trial: July 11, 1890.

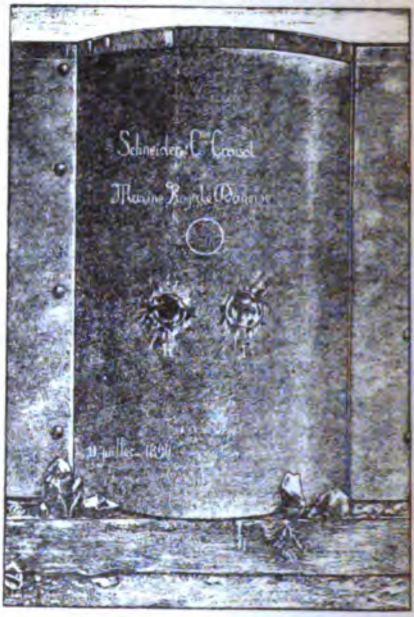
Details of plate: Dimensions, 7.38 feet high, 4.85 feet wide, and 4.5 inches thick at points of impact; weight, 3.14 tons. The points of impact were at the apexes of an equilateral triangle of 2¼ calibres length of side and with it base horizontal. The plate was secured to its backing of 23.6 inches of wood by 15 bolts. The radius of curvature of the plate was 29.2 inches.

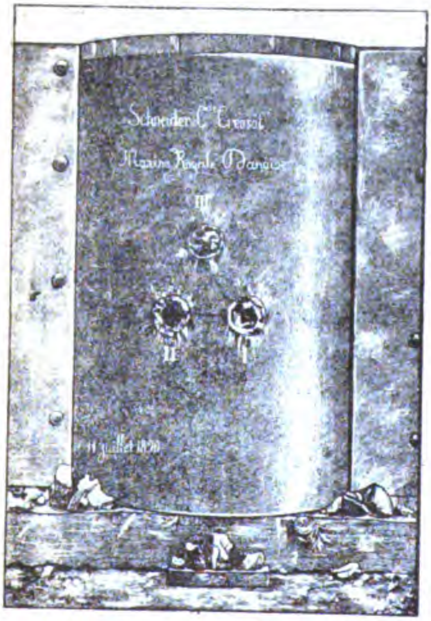
TRIAL NO. 9 CAPITAN PRAT PLATE PLATE IX

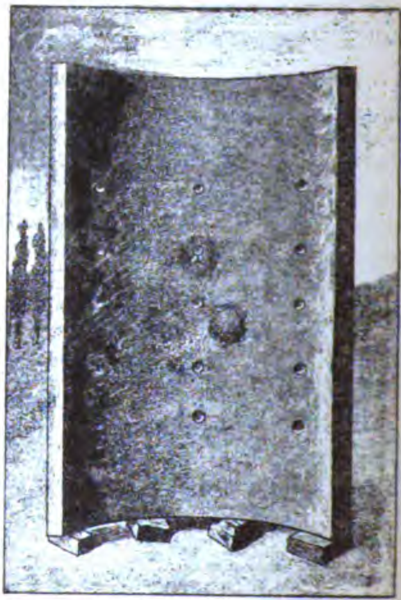


TRIAL NO. 10 TORDENSKJOLD & HEKLA PLATE. PLATE X.









Ballistical details.

[Gun, 15-centimetre (5.91-inch), 36-calibre, B. L. R.]

Projectile (Finspong armor-piercing cast steel)	pounds	90.4
Charge of S. P_2	do	16.3
Striking velocity	f. s.	1,236
Striking energy	f. t.	957.3
Energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		1.61
Range	feet	39.4

Firing details. (See Plate x.)

First shot.—The projectile penetrated 4.13 inches and broke up, its head remaining in the plate. A bulge 0.98 inches high and 8.7 inches in diameter was raised on the face of the plate. No cracks.

Second shot.—The projectile penetrated 4.21 inches and broke up. A bulge 1.02 inches high and 8.27 inches in diameter was raised on the face of the plate. The head of the first projectile dropped out of its shot hole. No cracks.

Third shot.—The projectile just got its nose through, making a star-shaped crack in back of plate, and broke up, its head remaining in the plate. A bulge 1.61 inches high and 9.45 inches in diameter was raised on the face of the plate. A fine surface crack was developed connecting the holes made by Nos. 1 and 2 shots.

In this trial of a curved plate, Finspong cast steel projectiles—a make of a. p. projectiles which ranks high—were used, and the striking energy corresponded to a penetration in steel of 4.9 inches.

The similar effects on plate and projectiles indicated the great homogeneity of the plate, and the amount of penetration and the trifling effect on the plate showed it to be, considering its thickness, superior in resisting power and uniformity of constitution to any Schneider plate previously tried, and also demonstrated the practicability of forming steel into curved plates without detracting from the resisting power of the metal.

In the preceding trials of steel plates we can find no basis of comparison with compound plates of corresponding dimensions. No extreme test has been used, as with English compound plates, by the employment of a. p. projectiles, except in the *Hekla* plate, which was too thin to allow us to make a comparison which would be fair to the much thicker compound plates treated of in this article. The chilled projectiles used are reported to be much superior to the Palliser, and the French employ them in preference to a. p. projectiles on account of their great uniformity in manufacture, a uniformity that has not yet been reached in the manufacture of even the best a. p. projectiles. Many years of exhaustive experiments have clearly demonstrated this fact to the Gavre Commission, and it is so well recognized that French manufacturers never find fault with the results obtained on their plates at the Gavre trials.

That the French plates were not unduly favored is proved by the striking energies employed, which, as compared with those necessary to just perforate wrought-iron plates of similar thickness, range from 1.35

to 1.64 per cent., while in the previously described English trials they did not exceed 1.35 per cent.

Admitting the claims made for the great uniformity of the French projectiles, the results of the preceding trials bring out the fact that, in the order in which these plates were made and tried, they have shown a gradual but decided improvement in resisting power, due, without doubt, to the fact that the simple metal of which they were composed has admitted of development in quality and in processes of manufacture.

The plates here treated of were all relatively thin, but as the resisting power of steel is known to depend on its qualities as a mass, it is but reasonable to suppose that its qualities as a protection against penetration will increase with increased thickness. This statement can not be applied to compound armor, the resisting power of which depends principally on its hard steel face.

The formula here used for finding the ratio of energies presupposes high velocities with small calibre projectiles, and as the velocities in all the steel plate trials were comparatively low the ratios of energy given are not exact. However, as they are not used to institute comparisons with compound plates attacked by high velocities, but only to show relatively the energy resisted by each plate, the error is not considered sufficient to necessitate, in this article, the use of a different formula for this one set of plates.

The thinness of plates, low velocities, and chilled projectiles used prevent us from forming any fair idea of the actual resisting power of these plates, but simply enable us to observe the steady improvement made in manufacture. And had it not been for the late competitive trials at Annapolis and at Ochta, the results of these French trials would still have left the question of the relative efficiency of steel and compound plates for armor protection in such a condition as to have permitted arguments in favor of each.

IV.

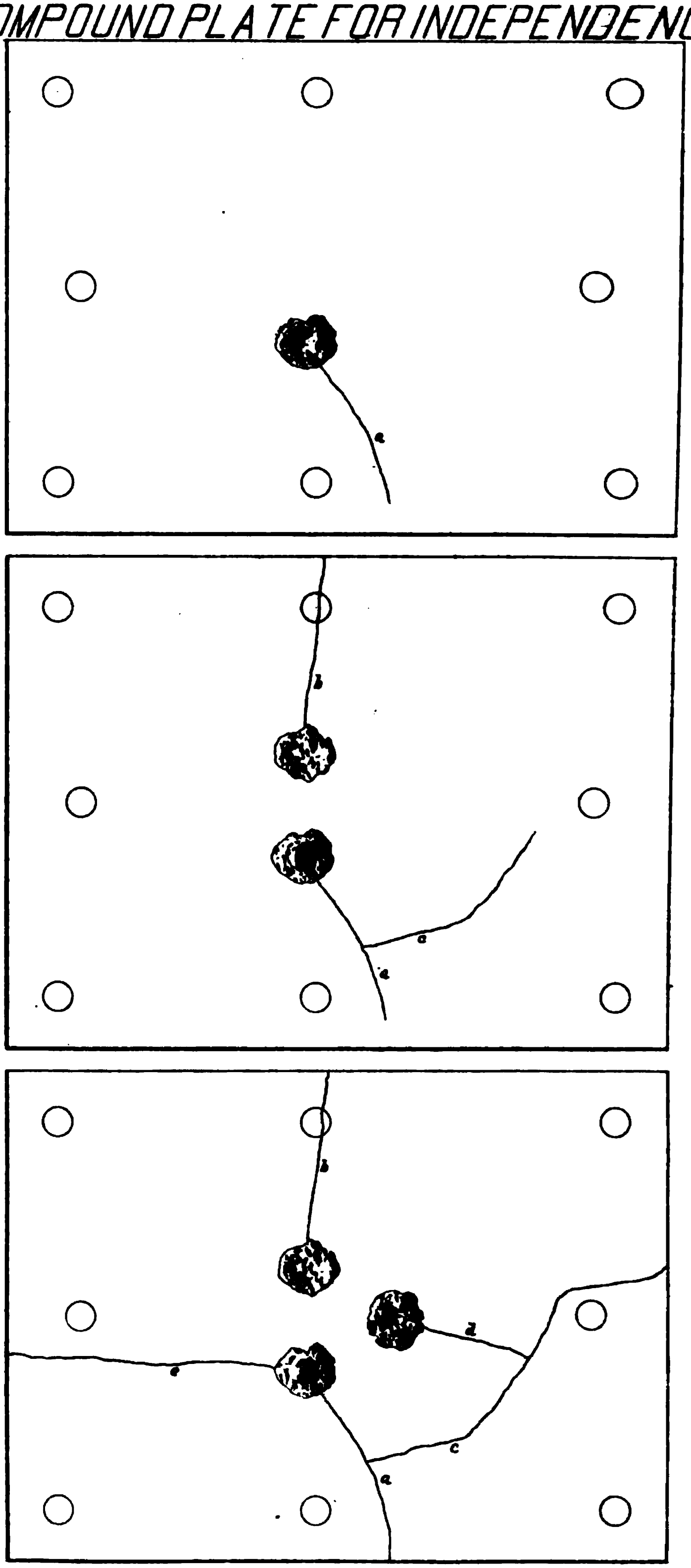
TRIAL OF A CAMMELL COMPOUND PLATE REPRESENTING THE ARMOR OF THE ARGENTINE COAST DEFENSE VESSEL INDEPENDENCIA.

It was the intention of the Argentine commission authorized to receive the armor for this vessel in England to have the conditions of the proof trial conform as nearly as possible to the proof trial at Gavre of the *Capitan Prat* plate previously described.

So much stress has been laid upon this statement in the public journals of this and foreign countries that, in order to show clearly how the conditions differed, we have decided to treat this trial separately from those of other English compound plates.

TRIAL NO. 11 PLATE XI.

COMPOUND PLATE FOR INDEPENDENCIA



TRIAL NO. 11.—*Test of a Cammell compound plate representing the armor of the Argentine coast-defense vessel Independencia.* (See Plate XI.)

Date of trial: February 3, 1891.

Details of plate: 8 feet long by 6 feet wide by 8 inches thick. Secured to an oak backing 5 feet 8 inches thick back of centre of plate, and 4½ feet thick elsewhere, by 8 bolts. Weight of plate, 6.8 tons.

Ballistical details.

[Gun, 6-inch B. L. R.]

Charge of E. X. E. powder	pounds..	32
Projectile: Palliser chilled cast-iron	do....	100
Range	feet..	30
Striking energy	f. t...	1,700
Energy as compared with that necessary to just perforate a wrought-iron plate of same thickness		1.25

Firing details. (See Plate XI).

One shot at each of the three corners of an equilateral triangle of 15-inch side and with base horizontal.

First shot.—Projectile penetrated 2.2 inches and point remained in plate. One surface crack, *a;* back bulge, 0.2 inch; projectile broke up.

Second shot.—Similar to first in penetration. One surface crack, *b*, running to left edge of plate, and one surface crack, *c*, running from crack *a*, well up the plate. Back bulge, .3 inches; projectile broke up.

Third shot.—Nearly similar result in penetration. Point of first shot fell out. Crack *c* extended to top of plate. Two new cracks, *d* and *e*, developed in face of plate. Back bulge, 0.2 inch; projectile broken up.

At each shot the point of the shell remained in plate. None of the cracks extended more than through the thickness of the face plate.

Notwithstanding the slight penetrations and the thick backing the give of the plate was sufficient to cause the blow at each shot to make a decided impress on the backing.

In comparing the conditions of this trial with those of the *Capitan Prat* we can find no points of similarity. This plate was cut down to the English standard size—8 by 6 feet—and did not represent a plate as intended to be placed on the ship, whereas the *Capitan Prat* plate was in every respect a counterpart of an actual plate for the vessel.

The *Independencia* plate had a uniform thickness of 8 inches, whereas the *Prat* plate was of varying thickness, that at the points of impact—6.3, 6.28, and 6.99 inches—being in each case much less than the thickness of the former.

In the *Independencia* plate the striking energy, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, was only 1.25, whereas in the *Prat* plate, taking the last shot, which struck a thickness of plate of only 6.99 inches, it was 1.39; and in any armor trial an extra comparative energy of 14 per cent. counts for a great deal. Even in the English official trials this ratio of energy is never less than 1.35.

The necessity for a rigid backing to bring out the powers of the compound plate is well illustrated here by the one foot extra thickness behind that part of the plate attacked, notwithstanding which the effect on the backing was greater than on that of the *Prat*.

Of the projectiles employed the Palliser is reputed to be much inferior to the French projectiles used at Gavre. As to the result on the *Independencia* plate, no other could have been expected. The poor quality of projectiles and the low striking energy employed could only bring out what has always been admitted as a fact—the peculiar power of the hard steel face of compound plates to break up projectiles of poor or medium quality. This test was entirely unnecessary to prove what has been demonstrated by every test of a Cammell plate when attacked by 6-inch Palliser projectiles. In trials of standard English plates, it is seldom that the two Palliser projectiles used have had a greater effect on the plate than is seen in the test of the *Independencia's* armor. This is shown in trial No. 1, where the penetrations of the Pallisers were no greater than in this case.

In consequence of all this we can not see that the trial here described has resulted in giving any real idea of the value of the plate; either for armor protection for a vessel or as compared with that for the *Capitan Prat.*

In connection with this trial we may recall that all notable victories achieved by compound armor have been with comparatively thin plates, and it is generally admitted that, down to a certain limit, compound armor can be better worked and made more homogeneous in thin plates than in thick ones.

V.

A COMPARISON OF ENGLISH COMPOUND, VICKER'S STEEL, SCHNEIDER'S STEEL, AND SCHNEIDER'S NICKEL-STEEL ARMOR PLATES FROM THE RESULTS OBTAINED IN THE RECENT COMPETITIVE TESTS AT OCHTA AND ANNAPOLIS.

Probably the most important and conclusive armor trials ever undertaken were carried out by the Russian and United States naval authorities during the past year.

These are interesting not only on account of the definiteness of the results obtained, but also from the fact that in each case the plate which fairly carried off the honours was neither one of the old-time rivals—English compound and Schneider steel—but was one of an alloy of nickel with steel.

And, in addition, we find projectiles used which were so little damaged on impact that the effects on the competing plates can be fairly compared, and, as it can not be supposed that the respective makers sent samples of any but their best work, the results can be accepted as of practical value.

The trial in the United States took place first, but as the nickel-steel plate tested there was made about a year after the one tested at Ochta, we will give precedence to the details of the Russian trial.

It is well to note that these trials were public and that no precautions were taken to insure secrecy. The plates for the Annapolis trial were purchased without any intimation on the part of the Navy Department to the makers as to the use to which they were to be put. The plates were therefore the property of the United States Government to do what it pleased with, and the trial was conducted with a view to satisfy our naval authorities, unbiased by the conflicting interests of competing manufacturers, as to the best system of armor for our new ships. It was therefore obviously to the advantage of our Government that the trial should be conducted in the most open and public manner, and the discussion of results which was sure to follow could only be of benefit to the parties principally interested.

COMPETITIVE TRIAL OF ARMOR PLATES AT THE OCHTA NAVAL BATTERY, RUSSIA.

(See Plates XII, XIII, and XIV.)

Date of trial: November 11th, 1890.

Details of plates: A Brown (Ellis patent) compound plate, a Schneider nickel-steel plate, and a Vickers all-steel plate, each 8 feet square by about 10 inches thick, and of a weight of about 11.7 tons.

Backing.—Each plate was bolted to layers of 12 inches of pine, and 1¼ inches of iron plating; the Brown plate by eight 3.82-inch bolts 25.4 inches long; the Schneider plate by twelve 3.12 inch bolts 21.6 inches long; and the Vickers plate by twelve 3.72-inch bolts 25 inches long.

Firing details.—The gun used was an Aboukoff 6-inch, 35 calibre, B. L. R., model 1877. The projectiles were made in Russia by Holtzer's workmen and were 16.06 inches in length, each weighing 89.38 pounds. The two first ones fired at each plate were from a lot insufficiently tempered and the remaining three from a lot better tempered. The two first shots at each plate were fired with charges of 53 pounds of Schlüsselburg brown powder, and the remaining rounds with charges of 54 pounds of Ochta brown powder, made in 1890.

Range, 361 feet.

The mean striking energy of the three last shots at each plate, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, was 1.44.

All through cracks will be denoted by the letter *t*.

Round 1.—First shot at compound plate. (See Plate XII.) Striking velocity, 1,975 f. s. Striking energy, 2,417 f. t. Point of impact, 25 inches from left edge and 26 inches from top.

Projectile penetrated 13.2 inches and remained in plate, scaling off some of the steel face about shot hole and developing one through crack extending to left edge of plate, and several surface cracks. Projectile apparently entire. Bulge at back of plate 24 inches in diameter, projecting 6 inches.

Round 2.—First shot at Schneider plate. (See Plate XII.) Striking velocity, 1,983 f. s.; striking energy, 2,436 f. t. Point of impact, 24 inches from left edge and 22 inches from top. Projectile penetrated 9 inches and rebounded broken in two at the bourrelet. Two through cracks, one to the top of plate and the other to the left edge. Back bulge 12 inches in diameter, projecting 1¼ inches.

Round 3.—First shot at Vicker's plate. (See Plate XII.) Striking velocity, 1,983 f. s.; striking energy, 2,436 f. t. Point of impact, 24 inches from left edge and 20 inches from top. Projectile penetrated 14 inches and rebounded entire. Several short cracks. Back bulge 18 inches in diameter, projecting 3¼ inches.

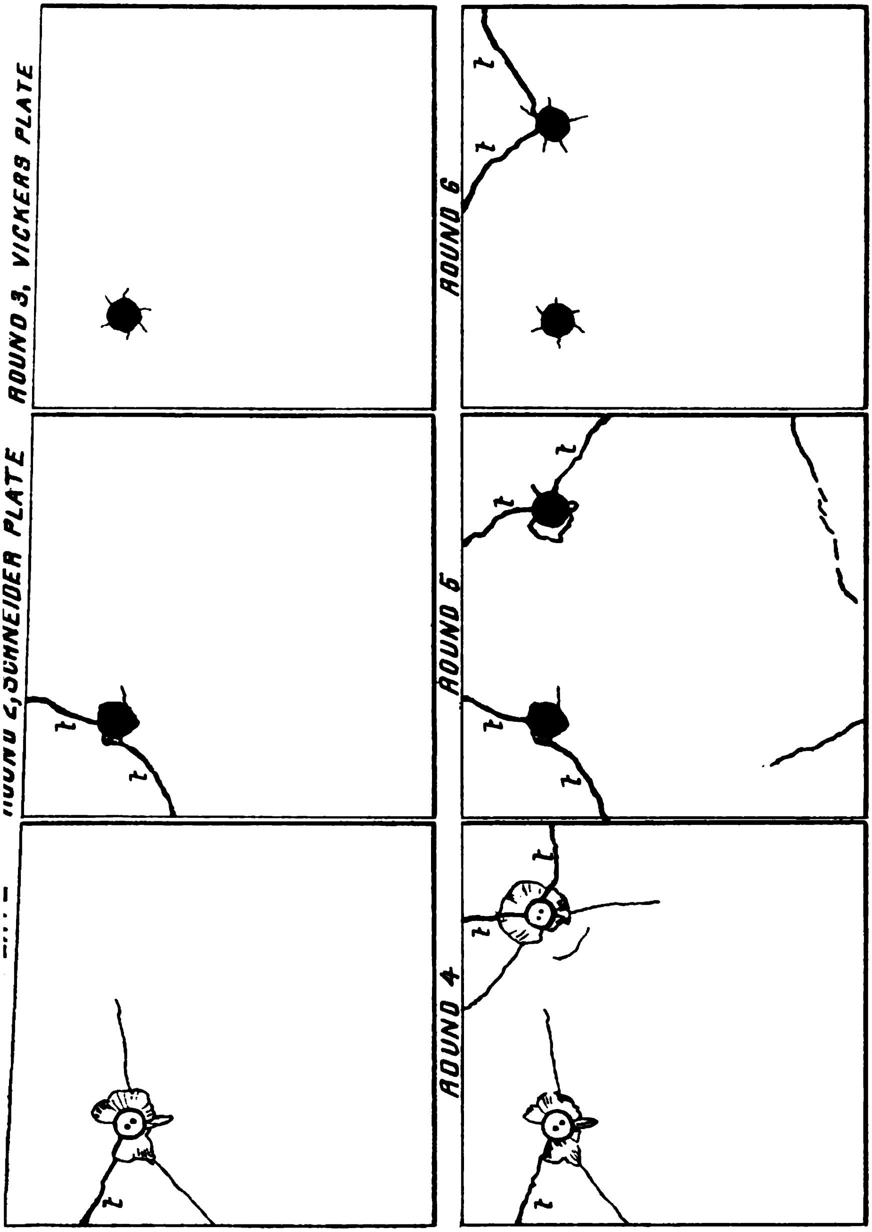
Round 4.—Second shot at compound plate. Striking velocity, 1,983 f. s.; striking energy, 2,436 f. t. Point of impact, 23 inches from right edge and 21 inches from top. Same penetration and same result on projectile as at round 1. Two through cracks, several radial surface cracks, and one short concentric surface crack. Back bulge 16 inches in diameter, projecting 5¼ inches. Considerable scaling off of steel face about shot hole.

Round 5.—Second shot at Schneider plate. Striking velocity, 1,996 f. s.; striking energy, 2,468 f. t. Point of impact, 25 inches from right edge and 24 inches from top. Projectile penetrated 8¾ inches and rebounded broken in three pieces. Two through cracks from shot hole, and crescent-shaped surface cracks on lower part of plate.

Back bulge 12 inches in diameter, projecting 1¼ inches.

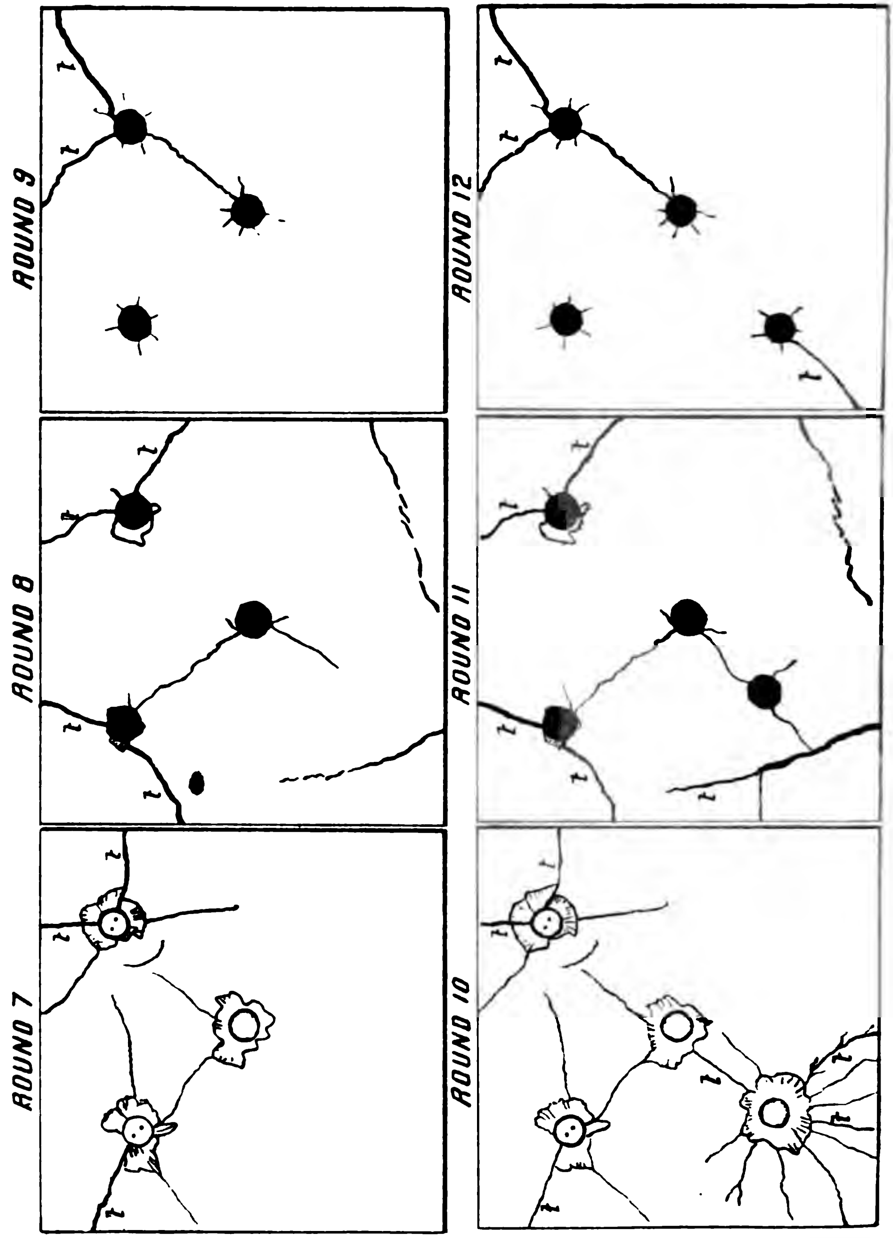
Round 6.—Second shot at the Vicker's plate. Striking velocity, 1,981 f. s.; striking energy, 2,431 f. t. Point of impact, 26 inches from right edge and 23 inches from top. Projectile penetrated 12¼ inches and rebounded unbroken. Two through cracks and several short surface radial cracks. Bulged part broken off from back of plate to a maximum diameter of 19 inches.

OCHTA ARMOR TRIALS PLATE XII.



OCHTA ARMOR TRIALS

PLATE XIII.



Round 7.—Third shot at compound plate. (See Plate XIII.) Striking velocity, 2,085 f. s.; striking energy, 2,694 f t. Point of impact, 47 inches from right edge and 49 inches from bottom. Projectile perforated plate and backing and was found unbroken 817 yards to the rear. Several cracks, but none apparently through plate, although when plate was taken down a through crack was found extending to first shot hole. Considerable scaling off about shot hole. Back bulge 24 inches in diameter, projecting 7½ inches.

Round 8.—Third shot at Schneider plate. Striking velocity, 2,084 f. s.; striking energy, 2,691 f. t. Point of impact at center of face. Projectile penetrated 11½ inches and rebounded unbroken. Two radial cracks which, when plate was taken down, were found to extend through the plate. All previous cracks enlarged. Bulged part broken off from back of plate to a diameter of 16 inches.

Round 9.—Third shot at Vicker's plate. Striking velocity, 2,089 f. s.; striking energy, 2,704 f. t. Point of impact 46 inches from right edge and 49 inches from bottom. Projectile penetrated 17 inches and remained in plate apparently unbroken. One radial crack to second shot hole which afterward developed through plate. A number of short radial surface cracks. Previous cracks enlarged. Bulged part broken off from back of plate to a diameter of 18 inches.

Round 10.—Fourth shot at compound plate. Striking velocity, 2,081 f. s.; striking energy, 2,684 f. t. Point of impact 27 inches from left edge, 24 inches from bottom. Projectile perforated plate and backing and was found unbroken 933 yards to the rear. A number of radial cracks, two at lower part extending through plate, and one running up to third shot hole. Back bulge 22 inches in diameter, projecting 8 inches.

Round 11.—Fourth shot at Schneider plate. Striking velocity, 2,081 f. s. striking energy, 2,684 f. t. Point of impact 30 inches from left edge, 26 inches from bottom, and 18 inches from a crack to the left. Projectile penetrated 9¾ inches and broke into two pieces. The above mentioned crack was extended through plate with a short deep crack extending to left edge. Several short radial cracks. Back bulge 15 inches in diameter, projecting 3 inches.

Round 12.—Fourth shot at Vicker's plate. Striking velocity, 2,073 f. s.; striking energy, 2,663 f.t. Point of impact 23 inches from left edge, 24 inches from bottom. Projectile penetrated 21 inches and remained in plate unbroken. One through crack to lower left hand corner and several short radial surface cracks. Bulged part broken off from back to a maximum diameter of 18 inches.

Round 13.—Fifth shot at compound plate. (See Plate XIV.) Striking velocity, 2,085 f. s. Striking energy, 2,694 f. t. Point of impact 22 inches from right edge and 24 inches from bottom. Projectile perforated plate and backing, and was not afterwards found. Considerable scaling of face about shot hole. Three through and several surface radial cracks, the upper through crack connecting with a deep crack developed at second shot, forming a through crack connecting the second and fifth shot holes. Back bulged to a diameter of 29 inches, projecting 8 inches, and with a part scaled off.

Round 14.—Fifth shot at Schneider plate. Striking velocity, 2,071 f. s. Striking energy, 2,658 f. t. Point of impact 23 inches from right edge and 25 inches from bottom. Projectile penetrated 10¼ inches and rebounded unbroken. Three radial through cracks. The surface crack developed at the second shot at this plate extended through, and a new through crack developed from it to right edge of plate, the enclosed piece separating slightly from the plate. Back bulge 20 inches in diameter, projecting 4¼ inches.

Round 15.—Fifth shot at Vicker's plate. Striking velocity, 2,067 f. s. Striking energy, 2,647 f. t. Point of impact 23 inches from right edge and 25 inches from bottom. Projectile penetrated 14 inches and rebounded unbroken. Two deep through radial cracks, one to lower right-hand corner and one to third shot hole. A through crack developed from second shot hole to right edge of plate. Bulged part broken off from back to a diameter of 19 inches.

Total of striking energies at each plate.

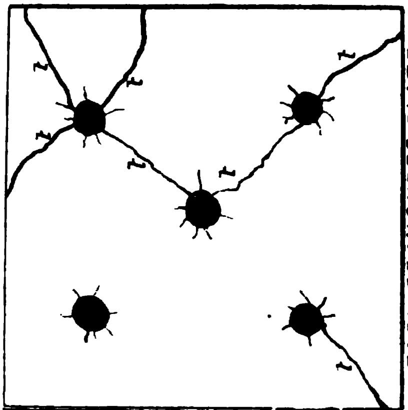
At compound plate	f. t.	12,925
At Schneider plate	do.	12,937
At Vicker's plate	do.	12,661

Here the Brown plate was completely outmatched. This does not show clearly for the two first shots, which is accounted for by the admitted fact that the two first projectiles fired at each plate were inferior to those afterwards used, being considerably softer. This is well shown on all the plates by the greater penetrations of the three last shots.

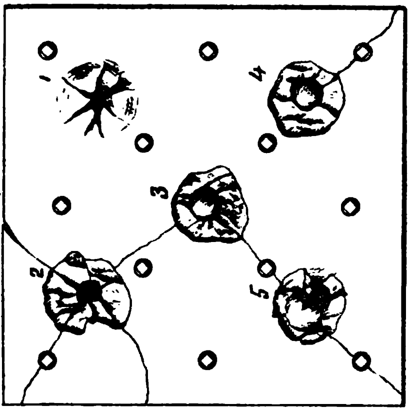
In addition to the much greater penetrations in the Brown plate it was also badly fractured, an unusual occurrence when a compound plate of such thickness is attacked by small projectiles, but the slight scaling off of the hard steel face showed that the welding of face and back was excellent. Its performance proved that it did not merit classing with its competitors, and had it been on a ship's side the large amount of bulging of the back would have seriously injured the framing behind it.

The Vicker's plate did comparatively well, but its resisting power was far below that of the Schneider plate, this being clearly evidenced by the greater penetrations, and by the less amount of work done on the projectiles. Being much softer than the Schneider plate it was much less shattered. Its back was bulged out considerably at the first shot; enough, had the plate been on a ship's side, to have badly bent or perhaps broken the framing behind it. The remaining shots did not cause any great bulging of the back, but instead, the metal was clipped out around the shot holes. Although quite soft this plate proved incomparably superior to the Brown. After the trial, though through-cracked as shown, it was removed from its backing without having the cracked parts separate. Its lack of homogeneity was evidenced by the differ-

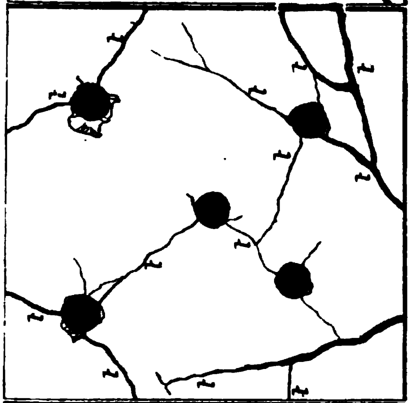
OCHTA ARMOR TRIALS PLATE XIV.



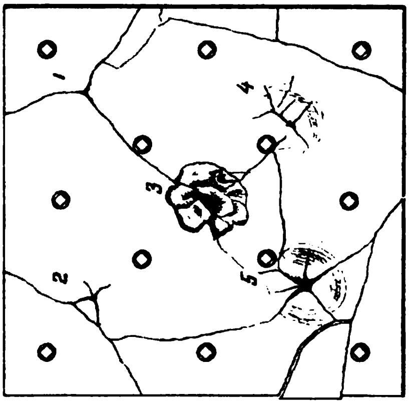
ROUND 15



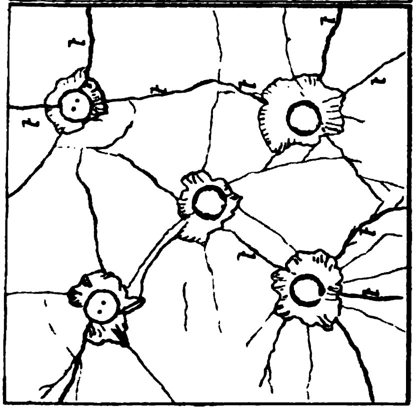
BACK OF VICKERS PLATE



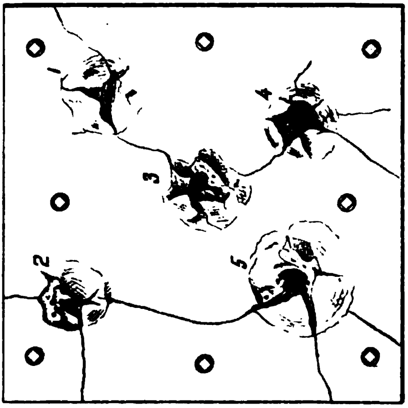
ROUND 14



BACK OF SCHNEIDER PLATE



ROUND 13



BACK OF BROWN PLATE

ence in penetration of the three last projectiles—17, 21, and 14 inches respectively—the projectiles all having remained unbroken. In many respects it reminds us forcibly of a steel plate for the *Torjenskjold* tested by Schneider with Creuzot-made steel projectiles in 1880, and which was made by Schneider's original process of manufacture, afterwards abandoned for the process now in use.

The Schneider nickel-steel plate did not show up as well as was expected, through cracking more than Vickers, but it proved to be the best plate of the three for armor protection. Only two of the projectiles got their points beyond the back of the plate, and had it been on a ship's side the framing behind it would have been practically uninjured. When removed from the backing this and the compound plate had to be banded to keep their fractured parts from separating. Had the steel and nickel-steel plates been on a ship's side, supported at their edges by companion plates, the excellent system of bolting employed would probably have caused the broken parts to remain in place, and they would still have been able to offer considerable resistance to perforation.

The rebounding of the projectiles from the nickel-steel plate showed it to be more elastic than the all-steel, the latter acting more like good wrought iron when attacked by projectiles of excellent quality. One especially noticeable feature with the nickel-steel plate should be kept in mind—that of the little effect of its many cracks on the penetration of succeeding projectiles.

As a result of this trial Schneider obtained a contract for 2,100 tons of armor for the Russian battle-ship *Georgy Pobedonetz;* and Vickers, who is well known as a manufacturer of excellent thin steel plates, a contract for about 300 tons of steel plates, from 3 to 5 inches thick, for two Russian gunboats.

A Kolpino (Russian) made Cammell compound plate was privately tested a few days after the Ochta trials took place, and, as most remarkable results have been claimed for it in the public prints, we will give the details here, simply to show that they were decidedly inferior to those obtained with the plates of Vickers and Schneider, described above.

Details of plate: Same as those of the Ochta plates.

Gun and backing: Same as those of the Ochta plates.

Projectiles.—Of steel, made at Putiloff works, Russia, tempered by the Holtzer process, and each weighing 99 pounds. Of the five used the two first and the two last were from a lot insufficiently tempered, and the third from a lot of harder temper.

The plate was secured to its backing by eleven 2.83-inch bolts.

Firing details.—These give results as determined before the plate was removed from its backing.

First shot.—Striking velocity, 1,949 f. s. Point of impact 26 inches from left edge and 24 inches from top. Projectile remained in plate, penetration not given. Only surface cracks.

Second shot.—Striking velocity not measured, but supposed to be same as above. Point of impact 20 inches from right edge and 26 inches from top. Projectile penetrated 12 inches and broke up. Some scaling of steel face about shot hole. Nine radial surface cracks.

Third shot.—Striking velocity, 2,094 f. s. with the hard projectile referred to above. Point of impact near center of face, 52 inches from right edge and 47 inches from bottom. Projectile perforated plate and backing. The point broke off and was found directly in rear of backing, the remainder of projectile being picked up 1,050 feet to the rear. A small piece of steel face fell off. Five radial cracks.

Fourth shot.—Velocity not recorded, but same charge was used as with third shot. Point of impact 25 inches from left edge and 23 inches from bottom. Projectile penetrated about 11.3 inches and remained in plate, visibly deformed, its plug being driven into the shell. Small piece of steel face broken off. Several surface cracks.

Fifth shot.—Velocity not recorded, but same charge was used as above. Point of impact 24 inches from right edge and 22¼ inches from bottom. Projectile penetrated 16 inches, lodging in plate with its base flush with the face. Ten radial cracks.

The back of the plate was not seen, but the above details are sufficient for all practical purposes.

The members of the Russian Artillery Technical Committee considered the nickel-steel plate the best, followed in order of merit by Vickers's. This Committee assigned the following coefficients of resistance to the plates tried at Ochta and the Kolpino plate referred to above.

Brown compound plate	[illegible]
Kolpino (Cammell) compound plate	[illegible]
Vicker's all-steel plate	[illegible]
Schneider's nickel-steel plate	[illegible]

ANNAPOLIS ARMOR TRIALS, SEPTEMBER, 1890.

The following account of this competitive trial of three armor plates, one of steel and one of nickel-steel, manufactured by Schneider & Co., Le Creusot, and one compound plate manufactured by Cammell & Co., Sheffield, comprises the greater part of the report made by the Board of Naval Officers appointed by the Secretary of the Navy to conduct the trial. The energy, as compared with that necessary to just perforate a wrought-iron plate of the same thickness was 1.50 with the 6-inch projectiles, and 1.61 with the 8-inch projectiles.

GENERAL DETAILS.

The Board made a careful preliminary inspection of the plates and their bolts and backing. They were all erected in accordance with a drawing furnished by the Bureau of Ordnance to the inspector of ordnance in charge at the proving ground. The steel plate and nickel-steel plate were secured to the backing with 12 bolts 2.36 inches diameter. The compound plate was secured to its backing by 8 bolts 3.1 inches in diameter.

Plate.	No. of bolts.	Diameter of bolts.	Total bolt cross section.	Weight of plate.	Bolt section per ton of plate.
			Sq. in.	*Pounds.*	*Sq. in.*
Steel	12	2.36″	52.29	*20,776	[illegible]
Nickel-steel	12	2.36″	52.59	*20,679	[illegible]
Compound	8	3.19″	64.32	†20,992	[illegible]

* Actual.

† Calculated.

Caliper measurements of armor plates.

[Commencing at lower right-hand corner, up right edge, across top and down left side, at intervals of 1 foot.]

Point of measurement.		Schneider, all steel.	Schneider, nickel-steel.	Compound.
		Inches.	*Inches.*	*Inches.*
Lower right corner		10.56	10.22	10.65
Right side	1	.61	.45	.68
	2	.61	.65	.76
	3	.58	.65	.81
	4	.53	.64	.70
	5	.52	.49	.76
	6	.51	.45	.80
	7	.53	.38	.70
Upper right corner		.55	.24	.70
Top	1	.59	.38	.69
	2	.60	.41	.71
	3	.61	.41	.77
	4	.63	.41	.75
	5	.63	.38	.74
Upper left corner		.55	.27	.67
	1	.56	.34	.70
	2	.51	.38	.59
	3	.55	.42	.67
	4	.53	.43	.71
	5	.58	.43	.67
	6	.63	.41	.69
	7	.63	.57	.76
Lower left corner		.50	.37	.76
	1	....	....	.83
	2	....	....	.82
	3	....	.30	.75
	4	....	....	.76
	5	....	....	.73
Mean		10.57	10.42	10.72

The surfaces of the plates were scoured clean.

The plates were arranged on chords of a circle with the gun pivot as the center and the muzzle of the gun 28 feet distant from the center of the plate towards which it was pointed, the axis of the gun being then normal to the surface of each plate.

The gun used was a 6-inch B. L. R., Mark III, 35 calibres long, mounted on a service centre pivot carriage. The charge used was 44½ pounds for each round; brown prismatic powder manufactured by Messrs. Du Pont. The striking velocity was 2,075 feet per second.

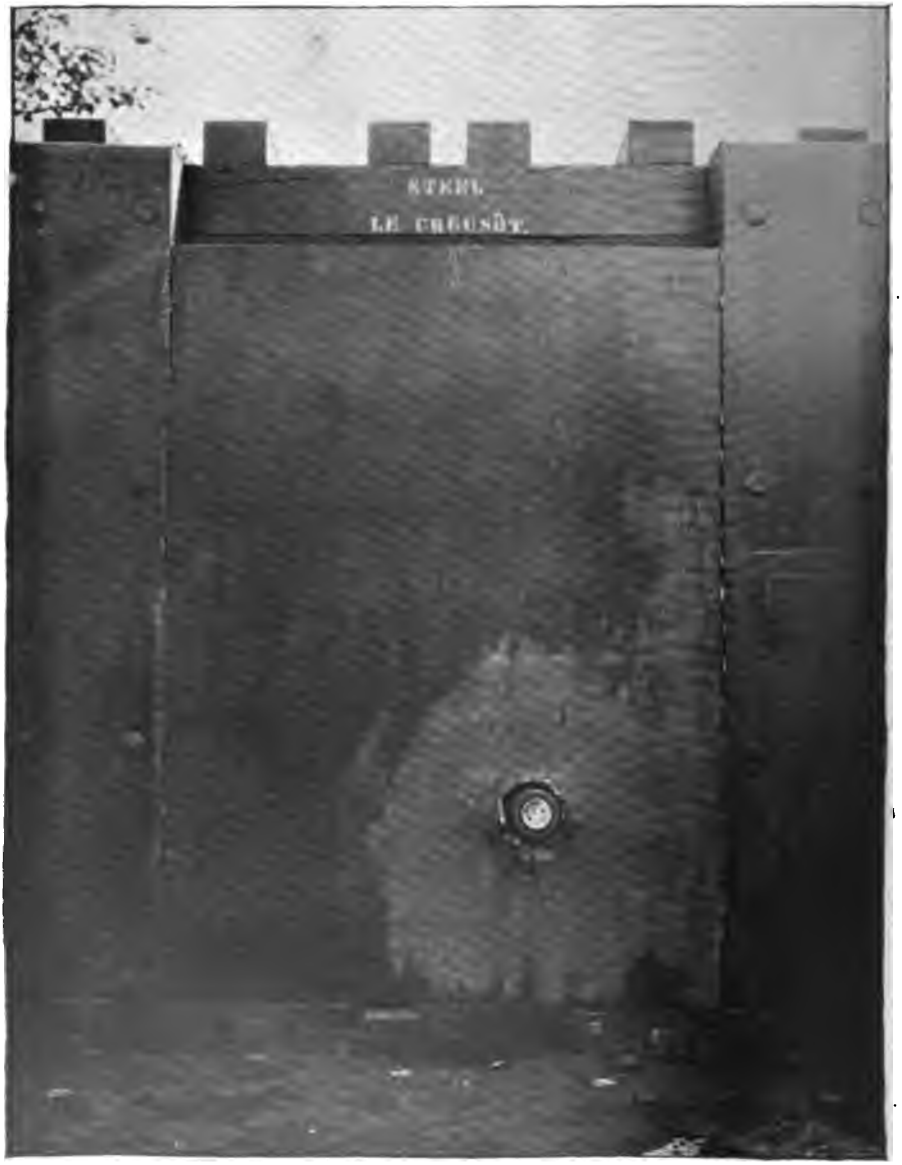
The projectiles were all Holtzer 6-inch armor-piercing shell, with ogival of 2 calibres radius, and were brought up to the standard weight of 100 pounds by filling them with sand and fragments of iron. These fragments of iron weighed about 2 ounces each.

The gun was mounted on a heavy wooden platform protected by a structure of timber roofed with iron plates and a pile of sand bags in front, through which the muzzle projected.

The pointing was done by means of central cross hair-sights in the axis of the bore.

Bomb-proofs had been erected at convenient places on the grounds. The one nearest the gun, at a distance of 50 feet protected the firing party. The gun was fired by means of friction primer and a long lanyard.

The Board caused photographs to be taken of each plate before and after each shot; of all three plates in a group after four shots each, and also after five shots each; of the recovered projectiles and ot such fragments of plate as could be identified.



STEEL PLATE AFTER FIRST SHOT.

FIRING TRIAL. FIRST DAY, SEPTEMBER 18, 1890.

ROUND 1.—*First shot at the steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the bottom and 24 inches from the right-hand edge of the plate. The projectile entered and remained in the plate with its base projecting 6.50 inches, and its body apparently intact. A bulge 1 inch high and 17.5 inches diameter was raised on the face of the plate, with a well-developed fringe projecting 1 inch. The visible portion of the hole in the plate was funnel-shaped, extending to a depth of 3 or 4 inches. Six short radial surface cracks were produced in the bulge. One small piece of fringe scaled off.

The side plates were uninjured; one bolt slightly started. The backing was undisturbed, and no bolts were started. The rotating band was stripped off the projectile. Its base-plug could still be easily turned.

ROUND 2.—*First shot at the compound plate.*

Gun: 6-inch B. L. R.

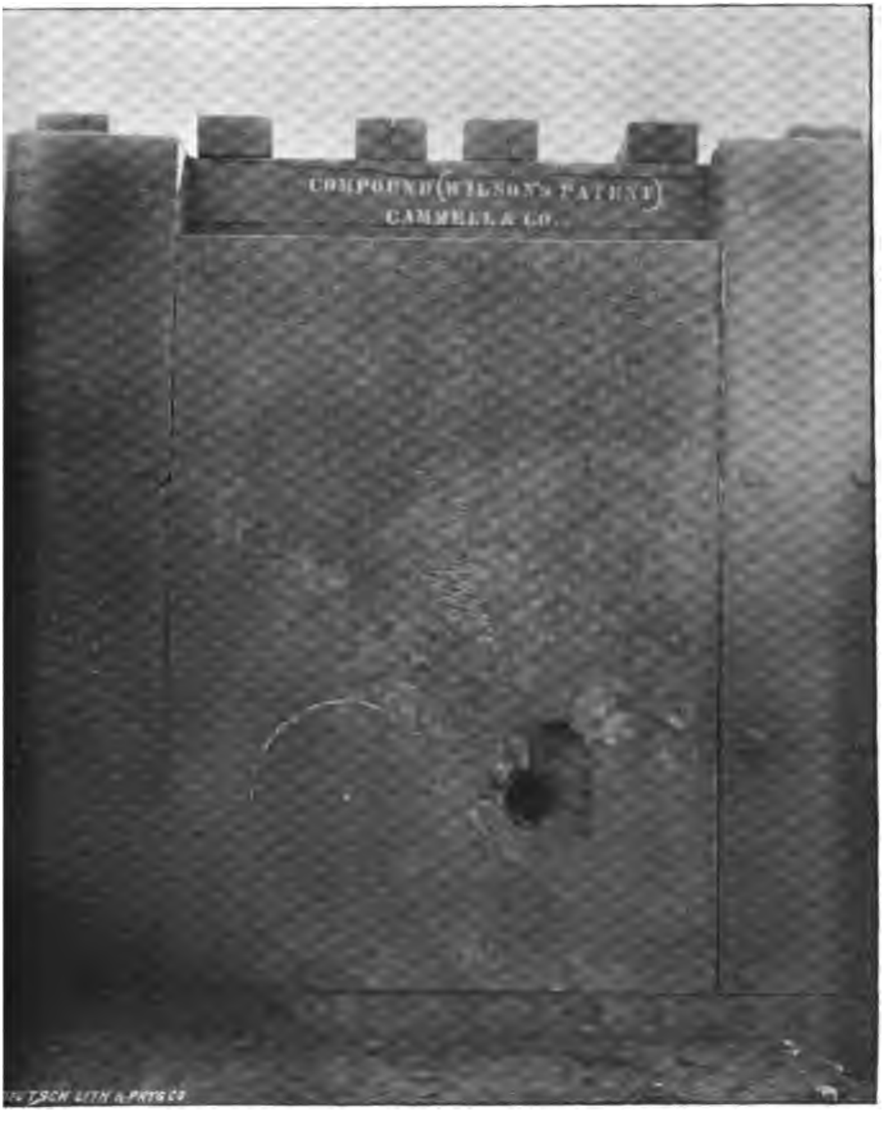
Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the right-hand edge and 24 inches from the bottom of the plate. The projectile perforated the plate and lodged in the backing, with its base at a distance of 21.5 inches from the face of the plate. Eight fine radial cracks were produced, varying in length from 24.5 to 55 inches from the center of the hole. One of these extended to the right edge of plate, at which point it seemed to extend through the steel face. The right-hand corner of the plate, along the through crack mentioned above, was set out to a distance of .10 inch. The steel face around the hole was scaled off to a diameter of from 14.5 to 19 inches, and to a depth of from 1.3 to 2.33 inches. The interior of the shot hole showed a rough surface.

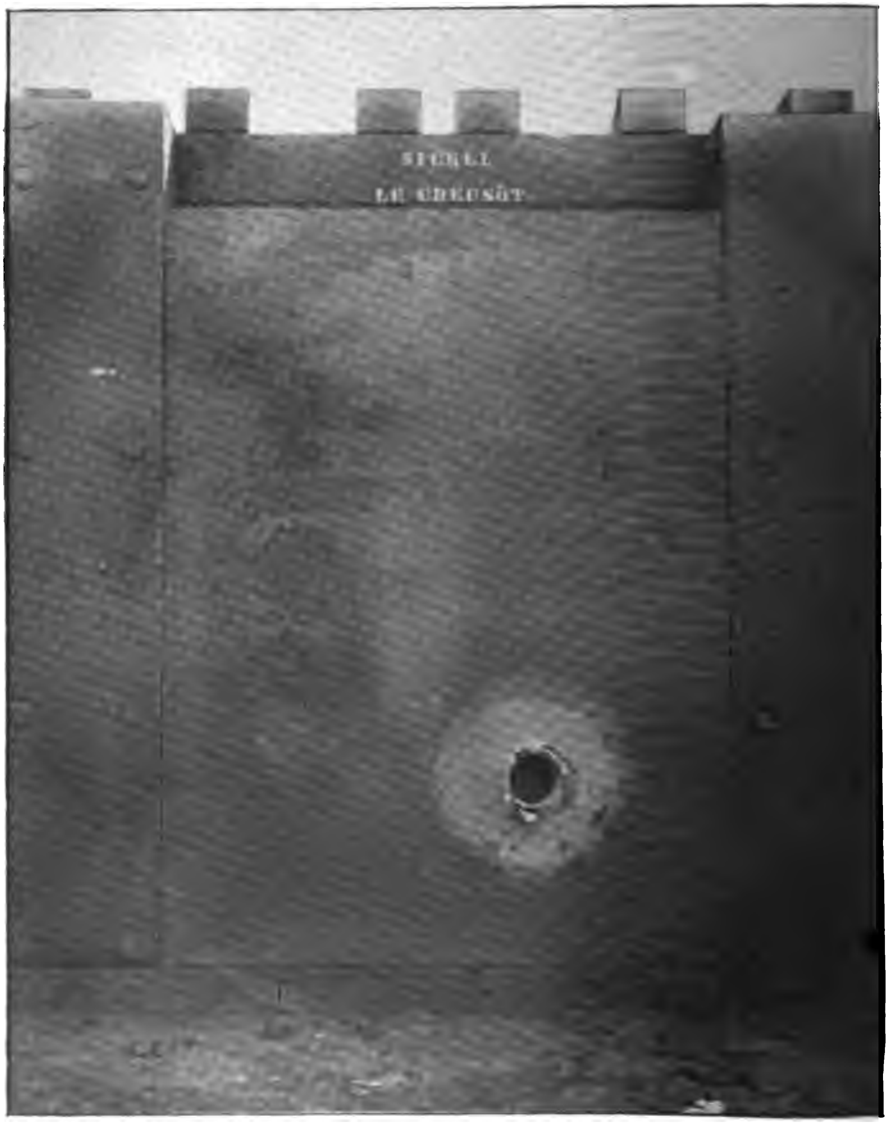
The side plates were uninjured. Two bolts of right-side plate near point of impact were slightly started. One tie-bolt of the backing, about 8 inches from the point of impact, was started 5 inches to the rear. The rear side of bolt-heads in first row of vertical bolts started one-tenth of an inch from the braces.

The two inner lower braces of the backing were started upwards and backwards .25 inch. The projectile remained buried in the backing with its face visible through the hole.



UTSCH LITH & PRTG CO

COMPOUND PLATE AFTER FIRST SHOT.



NICKEL-STEEL PLATE AFTER FIRST SHOT.

ROUND 3.—*First shot at the nickel-steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 ot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the right-hand edge, and inches from the bottom of the plate. The body of the projectile maained in the plate. The rear end, 7.5 inches long, broke off at a stance of 4 inches in from the face of the plate and rebounded 30 feet m the front. A front bulge was raised 17 inches in diameter and 25 inches high. There was no fringe.

Two short radial surface cracks were produced in the bulge. A small ce of the bulge, 1 inch deep, was scaled off from the side of the shot le.

The side plates were uninjured. The head of one bolt was split in o.

The bolt in backing nearest the point of impact was driven 30 inches the rear. The backing was undisturbed.

Round 4.—*Second shot at the steel plate.*

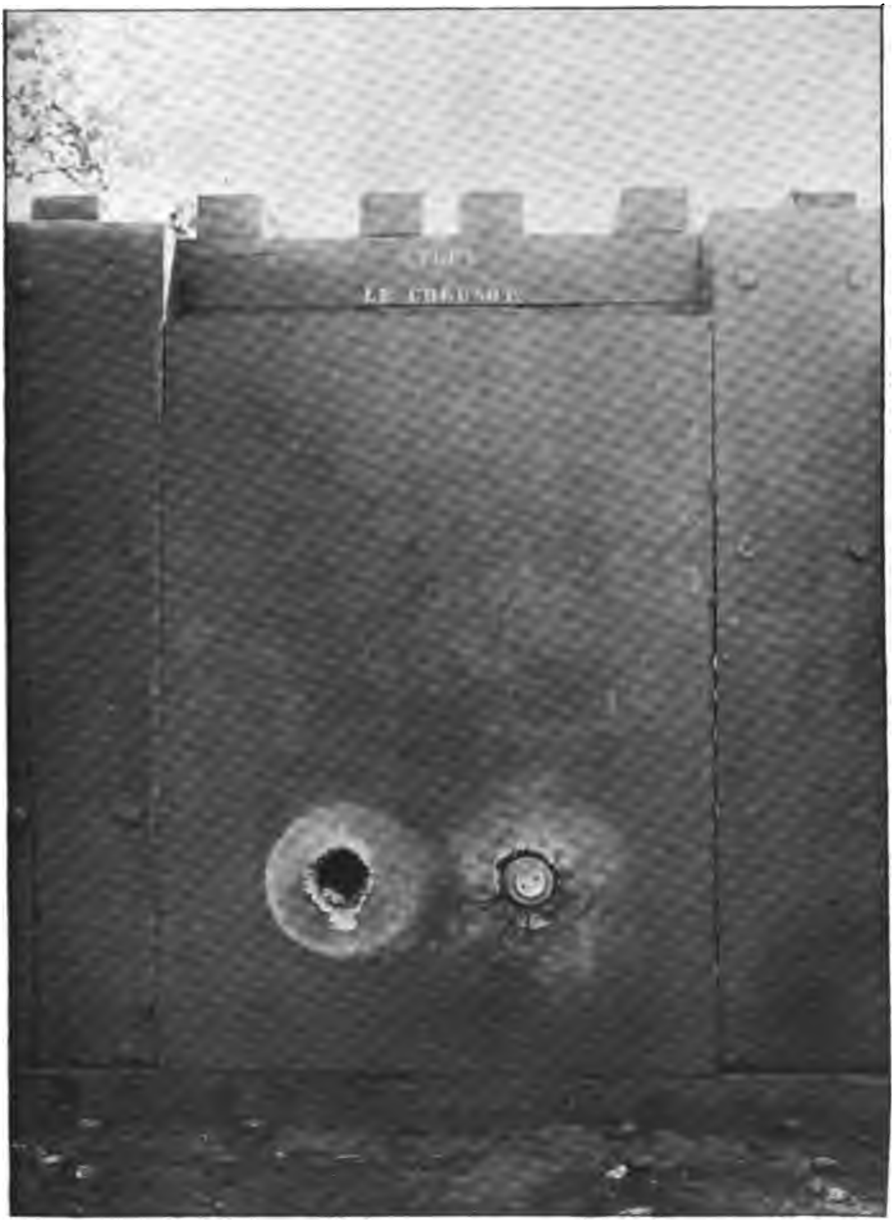
Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

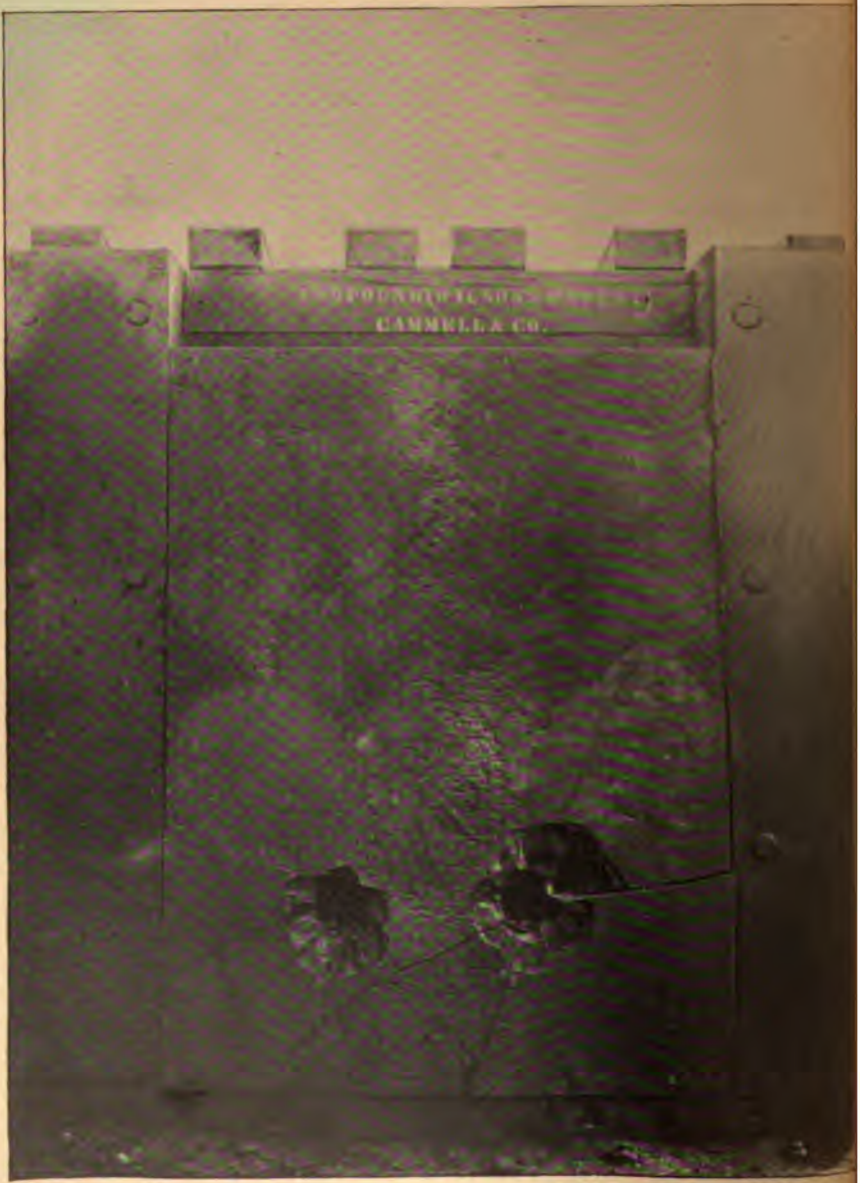
Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the left-hand edge, and 24 inches from the bottom of the plate. The projectile penetrated to a depth of 12 inches, and rebounded entire to a distance of 26 feet to the front and 3 feet to the right. It was shortened .10 inch. A front bulge was raised 18.5 inches diameter and 1 inch high, with a well-developed fringe projecting .75 inch. Seven short radial cracks were developed in the bulge, two of them being connected by two short surface hair cracks. One small piece of fringe scaled off. The shot hole was regular, with a smooth surface, and showing star-shaped cracks at inner extremity.

The side plates were uninjured. Two bolts were started. One nut of a side-plate bolt was broken off. The backing was undisturbed.



STEEL PLATE AFTER SECOND SHOT.



COMPOUND PLATE AFTER SECOND SHOT.

ROUND 5.—*Second shot at the compound plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,998 foot tons.

The point of impact was 24 inches from the left-hand edge and 24 inches from the bottom of the plate. The projectile perforated the plate and lodged in the backing with its base visible at a distance of 15 inches from the face of the plate. The steel face was scaled off the plate around the shot hole irregularly to an average diameter of 14 inches and a depth of 1.25 inches.

Six radial cracks were produced, all extending to the edges of the plate and apparently quite deep. A surface crack was produced about 3.5 feet above lower edge of plate extending nearly across the plate.

Two connecting radial cracks produced by the first shot deepened and were extended entirely across the plate through both shot holes, throwing out the lower part of the plate from 0.6 inch to 1.8 inches. Where this crack reached the right edge of the plate the steel face showed a vertical curved fracture of a minimum thickness of 0.3 inch and separated 1.9 inches at the top.

The interior surface of the shot hole was rough and broken, showing a disintegration of the metal, many small loose fragments of which were lying in the hole. The cracks developed by the preceding shot were all increased in size, the lower part of the plate being much racked.

The side plates were uninjured. Two bolts were slightly started.

The backing showed but slight set back. One tie bolt in backing nearest impact was driven 4 inches to the rear. The rear side of boltheads of first vertical row was started 0.10 inch from the braces.

ROUND 6.—*Second shot at the nickel-steel plate.*

Gun : 6-inch B. L. R.

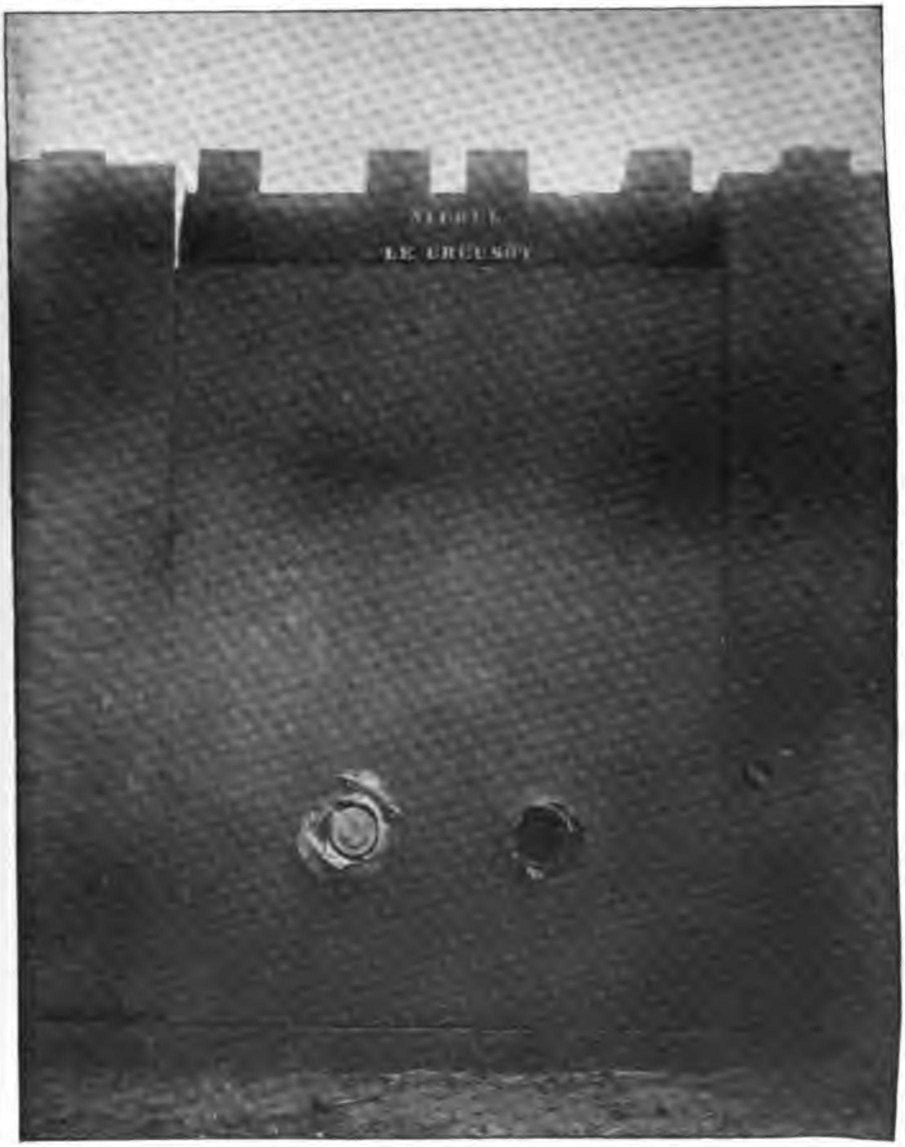
Projectile : Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge : 44½ pounds brown prism. Striking energy, 2,988 foot tons.

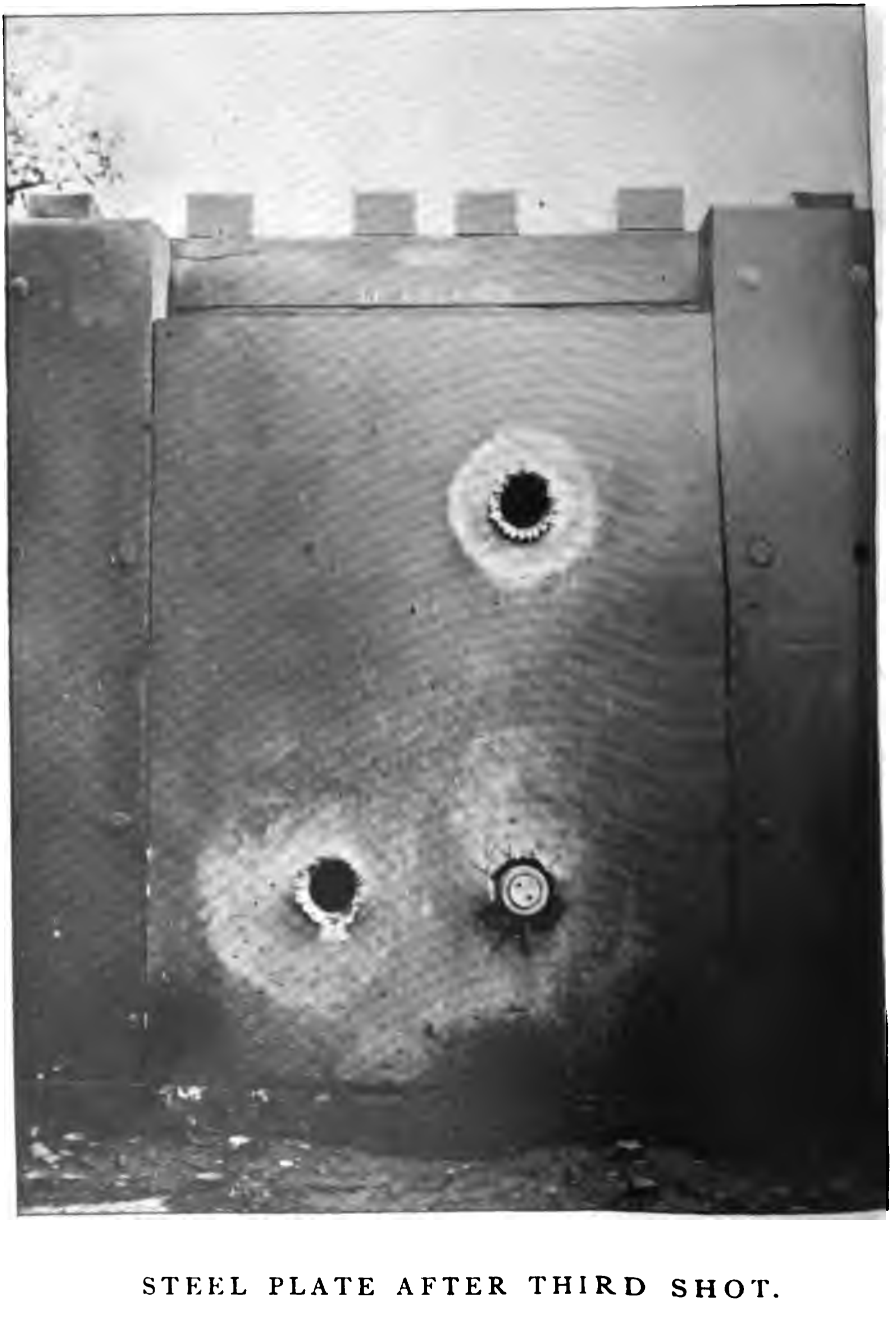
The point of impact was 24 inches from the left-hand edge, and 24 inches from the bottom of the plate. The projectile penetrated and remained in the plate apparently intact, its base projecting 1.6 inches. The rotating band was still in place, but sheared flush with the body of the shell.

A front bulge was thrown up 16 inches in diameter and 1.10 inches high. A piece was scaled off for about two-thirds the circumference of the bulge of an average diameter of 12.55 inches and average depth of 1.10 inches.

The side plates were uninjured, two bolts slightly started. The backing was uninjured. The tie bolt nearest the point of impact was driven 12 inches to the rear.



NICKEL-STEEL PLATE AFTER SECOND SHOT.



STEEL PLATE AFTER THIRD SHOT.

ROUND 7.—*Third shot at the steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the right-hand edge and 24 inches from the top of the plate. The projectile penetrated to a depth of 12.5 inches and rebounded entire to a distance of 30 feet. It was shortened .14 inch and the diameter of the bourrelet was increased .01 inch.

A front bulge was formed 18.5 inches diameter and 1 inch high, with a well developed fringe projecting 1 inch. Five short radial surface cracks were developed in the bulge, and two small pieces of the fringe were scaled off. The shot hole was smooth and regular, showing star-shaped cracks at its inner extremity.

The side plates were uninjured; one piece of bolt 7 inches long was broken off and thrown out to the front. The backing and its bolts were undisturbed.

ROUND 8.—*Third shot at the compound plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from right-hand edge and 24 inches from the top of the plate. The projectile perforated the plate and lodged in the backing, with its base 23.75 inches from the face of the plate.

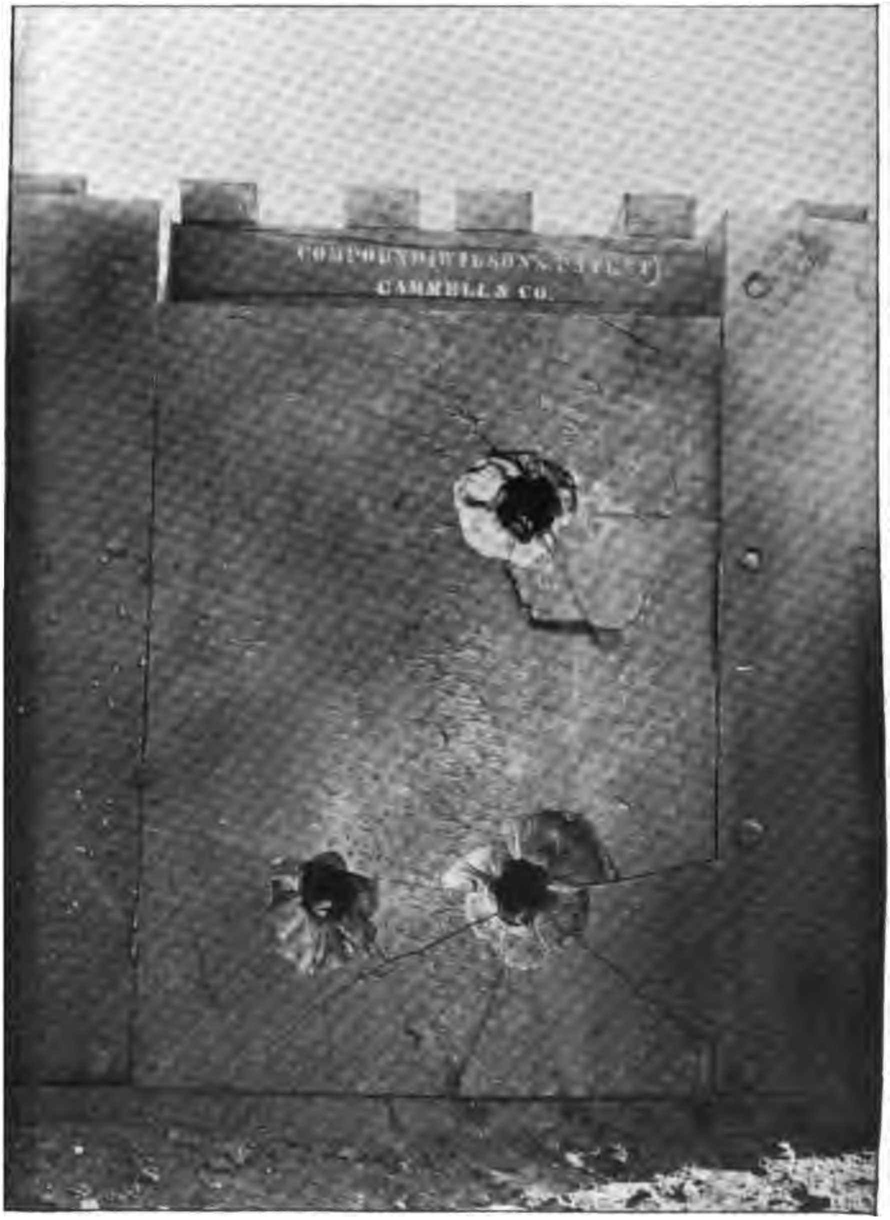
Ten deep radial cracks were produced, some of them being connected by cross cracks. A large piece of steel face in upper right-hand corner was slightly separated from the wrought-iron back, and a smaller piece was in the same condition below the shot hole.

Old cracks in lower part of plate were increased in size, and the face of the plate was quite shattered.

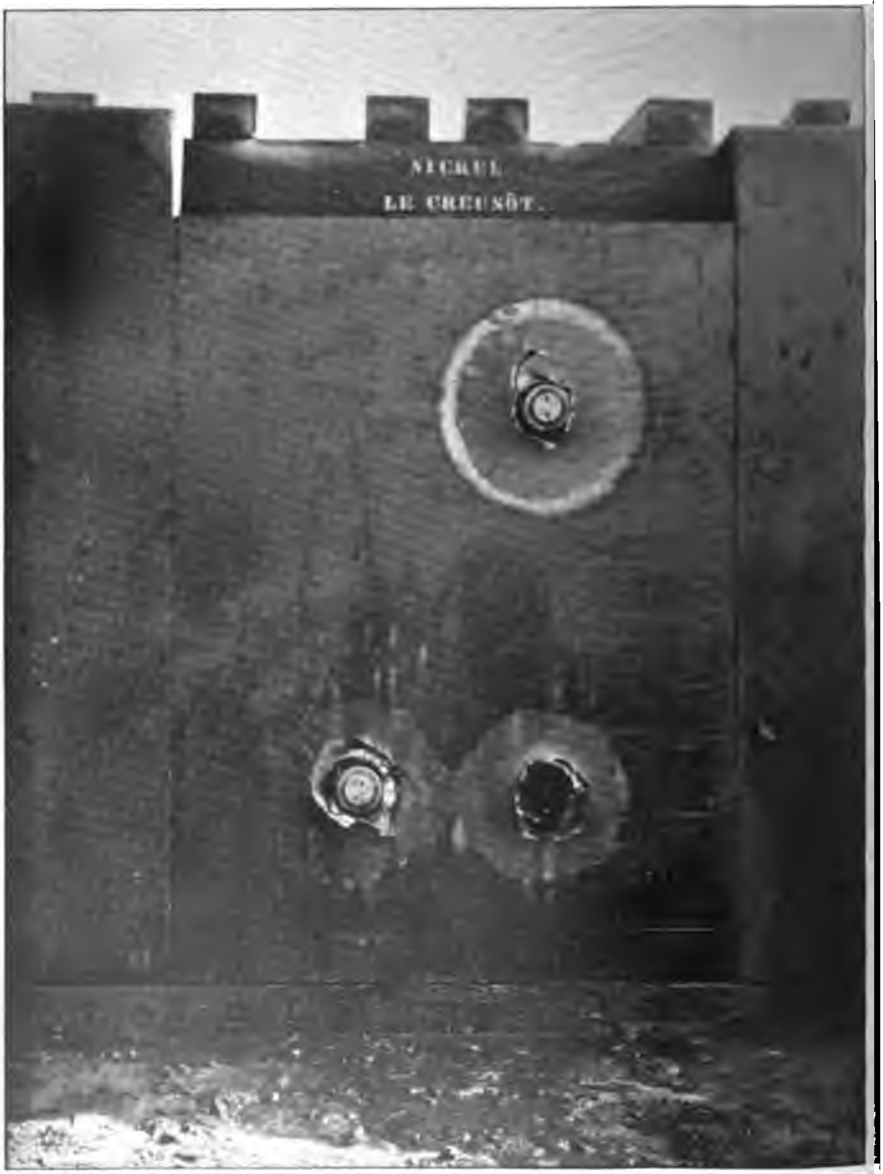
The interior surface of the shot hole was rough and broken, showing disintegration of the surrounding metal, many small fragments of which had been shaken off and were lying in the hole.

The side plates were not injured. The nuts of five bolts in the left-side plate were unscrewed from .25 inch to .50 inch.

The backing was uninjured.



COMPOUND PLATE AFTER THIRD SHOT.



NICKEL-STEEL PLATE AFTER THIRD SHOT.

ROUND 9.—*Third shot at the nickel-steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the right-hand edge and 24 inches from the top of the plate. The projectile penetrated and remained in the plate apparently intact, its base projecting 4.5 inches and its rotating band half torn off. A front bulge was raised 18 inches in diameter and 1.5 inches high.

Two very short radial surface cracks were produced in the bulge. Two small pieces scaled out of bulge. The side plates were uninjured; the bolt-heads were slightly bent.

The backing was undisturbed and no bolts were started.

ROUND 10.—*Fourth shot at the steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

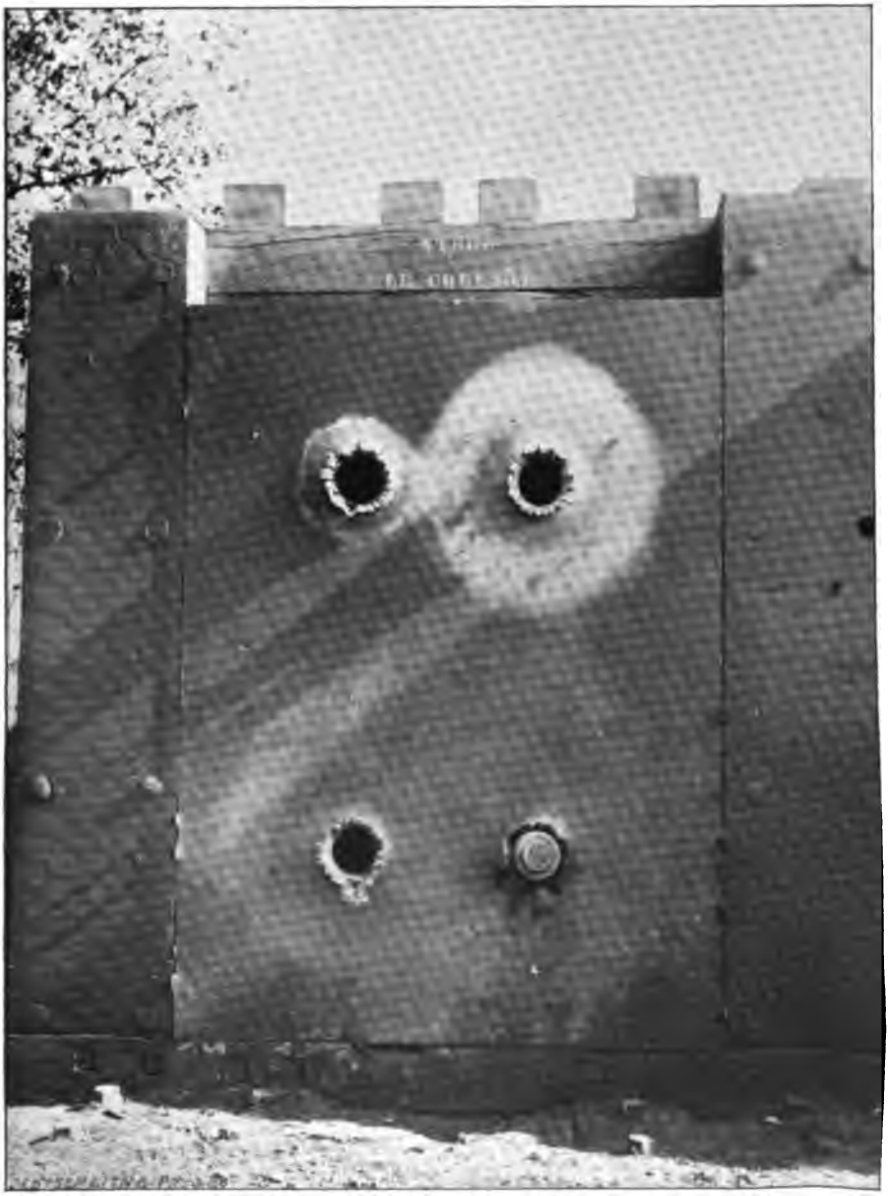
The point of impact was 24 inches from the left-hand edge and 24 inches from the top of the plate. The projectile penetrated to a depth of 12.5 inches and rebounded, breaking into three large and several small pieces. The head was entire, the body in halves, the transverse break at 7 inches from the base of shell.

A front bulge was raised 17 inches diameter and 1 inch high, with a well-developed fringe projecting 1 inch.

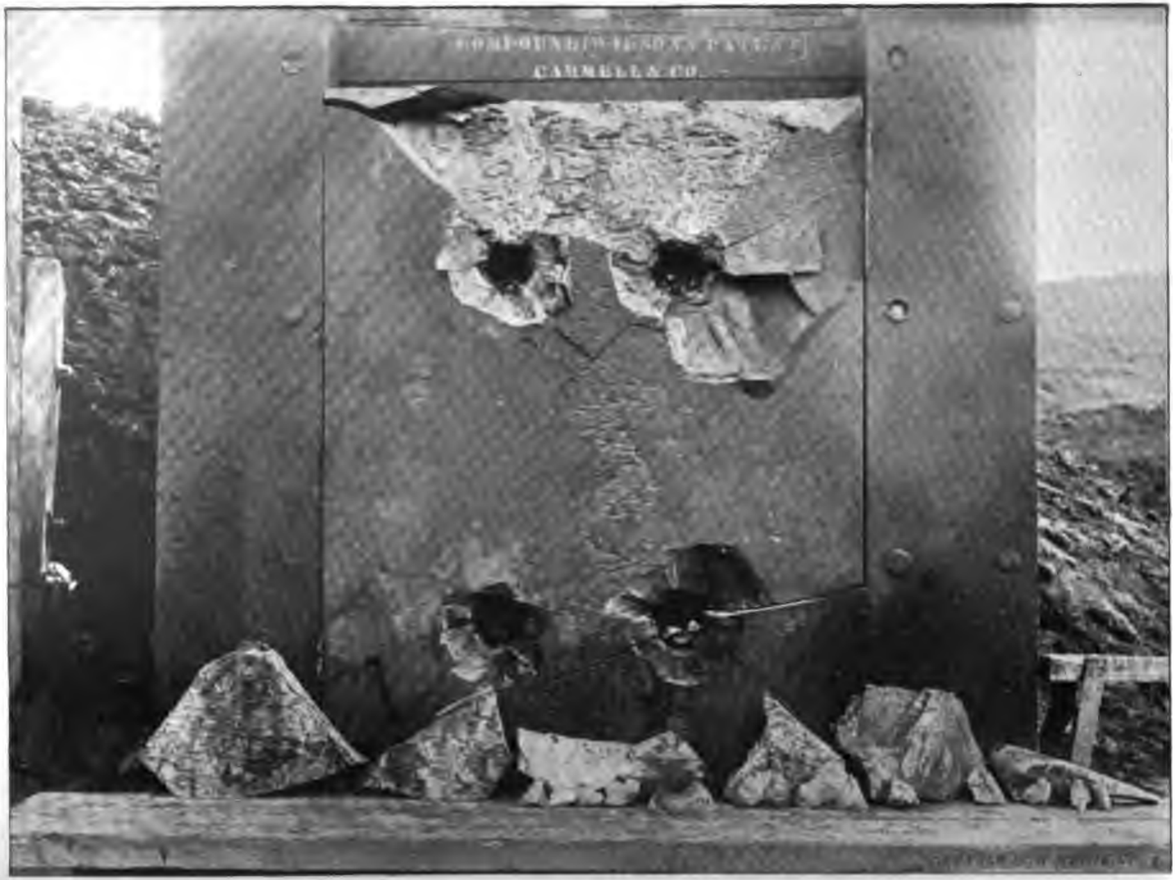
Six short radial surface cracks were produced in the bulge, and one small piece of the fringe was scaled off. The surface of shot hole was smooth and regular, showing star-shaped cracks at its inner extremity.

The side plates were uninjured.

The backing was undisturbed. One bolt, broken by previous shot, was driven to the rear 2 inches.



STEEL PLATE AFTER FOURTH SHOT.



COMPOUND PLATE AFTER FOURTH SHOT.

ROUND 11.—*Fourth shot at the compound plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the left-hand edge and 24 inches from the top of plate. The projectile perforated plate and backing, breaking into three large and several small pieces. The largest piece passed over the earth backing and lodged in the butt, 60 feet away.

Three deep cracks were developed below shot hole. All the steel face above this and the preceding shot hole separated from the wrought-iron back, and the greater part of it was thrown off in seven large and many small fragments, the larger fragments weighing, respectively, 29, 58, 92, 125, 178, and 380 pounds.

A part of the steel face below the preceding shot hole separated from the wrought-iron back and was thrown off.

All previous cracks widened.

That part of the wrought-iron back which was exposed on the upper part of the plate showed a rough, broken appearance and contained three narrow cracks. The shot hole was very rough on the interior surface, showing much disintegration of the metal, with small fragments of which it was nearly filled.

The remainder of the plate was badly racked and showed seventeen large cracks through steel face. The side plates were uninjured.

There was an irregular hole torn in the backing by the shot. No bolts were started.

ROUND 12.—*Fourth shot at the nickel-steel plate.*

Gun: 6-inch B. L. R.

Projectile: Holtzer a. p. shell, 100 pounds. Striking velocity, 2,075 foot seconds.

Charge: 44½ pounds brown prism. Striking energy, 2,988 foot tons.

The point of impact was 24 inches from the left-hand edge and 24 inches from the top of the plate. The projectile broke 3.5 inches from face of plate and 6.5 inches from its base, its head remaining in the plate. The rear half rebounded 30 feet, burying itself in the sand-bags around the gun.

A front bulge was raised 16 inches diameter and 1 inch high. One fine crack was developed in the upper part of the bulge.

The visible interior surface of the hole was smooth and regular.

The side plates were uninjured; bolt-heads slightly bent. The backing was undisturbed and no bolts were started.

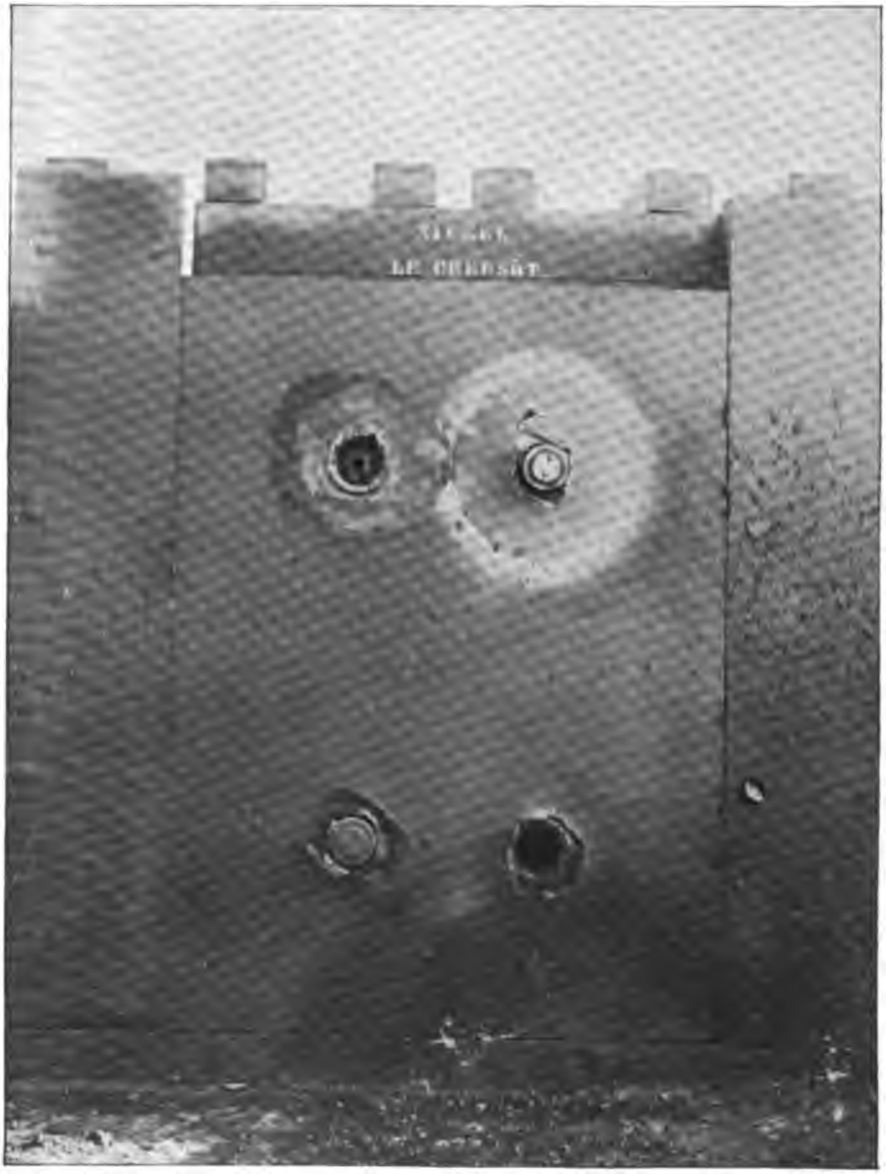
FIRING TRIAL.—SECOND DAY, SEPTEMBER 22, 1890.

After the preceding twelve rounds had been fired the Board adjourned for two days until an 8-inch gun, with which it was decided to continue the firing, could be mounted. The firing with this gun took place on Monday, September 22, 1890.

The gun was mounted on the same platform as the 6-inch, with its pivot 6½ feet to the rear of the 6-inch pivot. The muzzle of the gun was 30 feet distant from the plates.

The charge was 85 pounds of brown prismatic powder, made by Du Pont. The striking velocity was 1,850 feet per second.

The projectiles were Firth armor-piercing shell, weighted to 210 pounds by filling them with sand.



NICKEL-STEEL PLATE AFTER FOURTH SHOT.

[illegible] PLATE AFTER FIFTH SHOT.

ROUND 13.—*Fifth shot at the steel plate.*

Gun: 8-inch B. L. R.

Projectile: Firth a. p. shell, 210 pounds. Striking velocity, 1,850 foot-seconds.

Charge: 85 pounds brown prism. Striking energy, 4,988 foot-tons.

The point of impact was at the centre of the plate. The projectile penetrated to a depth of 15 inches and rebounded, broken in three large pieces. A front bulge was raised 21 inches in diameter and 1 inch high. There was no fringe. A piece scaled off from the lower right-hand edge of hole radially for 5 inches.

Four through cracks, radiating from the shot hole were developed, two above and two below, each one extending diagonally through one of the 6-inch shot holes to top and bottom of face respectively, and forming an irregular shaped X. These cracks above the centre hole varied in width from .25 to .50 inches, and below the centre hole from .16 to .50 inches.

The upper right hand crack reached the top at a point 13 inches from the side. The upper left-hand crack reached the top 5.5 inches from the side. The lower right-hand crack reached the bottom 13.25 inches from the side, and the lower left-hand crack reached the bottom 8 inches from the side of the plate.

The side plates were uninjured and the bolts intact.

The backing was driven back bodily .10 inch.

ROUND 14.—*Fifth shot at the nickel-steel plate.*

Gun: 8-inch B. L. R.

Projectile: Firth a. p. shell, 210 pounds. Striking velocity, 1,850 foot seconds.

Charge: 85 pounds brown prism. Striking energy, 4,988 foot-tons.

The point of impact was the centre of the plate. The projectile entered and broke 5.25 inches from the face of plate, part of the head remaining in the hole.

A front bulge was raised 16.5 inches in diameter and .25 inches high. The circumference of the hole was scaled out to the following radial distances from the centre:

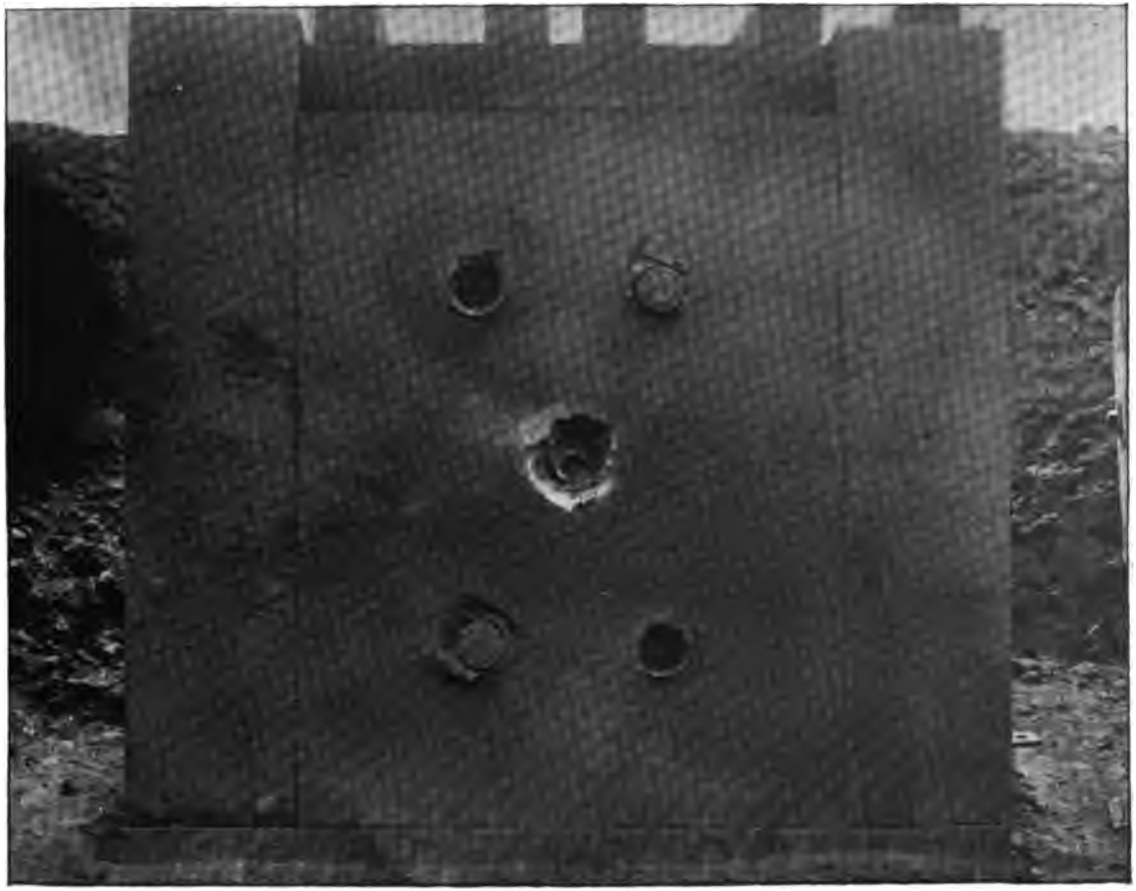
At top, 7 inches out, maximum depth 4 inches.
At right side, 6 inches out, maximum depth 2 inches.
At bottom, 6.5 inches out, maximum depth 2 inches.
At left side, 7.25 inches out, maximum depth, 4 inches.

A hole of considerable length was visible on the side of the interior of the hole between the projectile and interior surface of the plate.

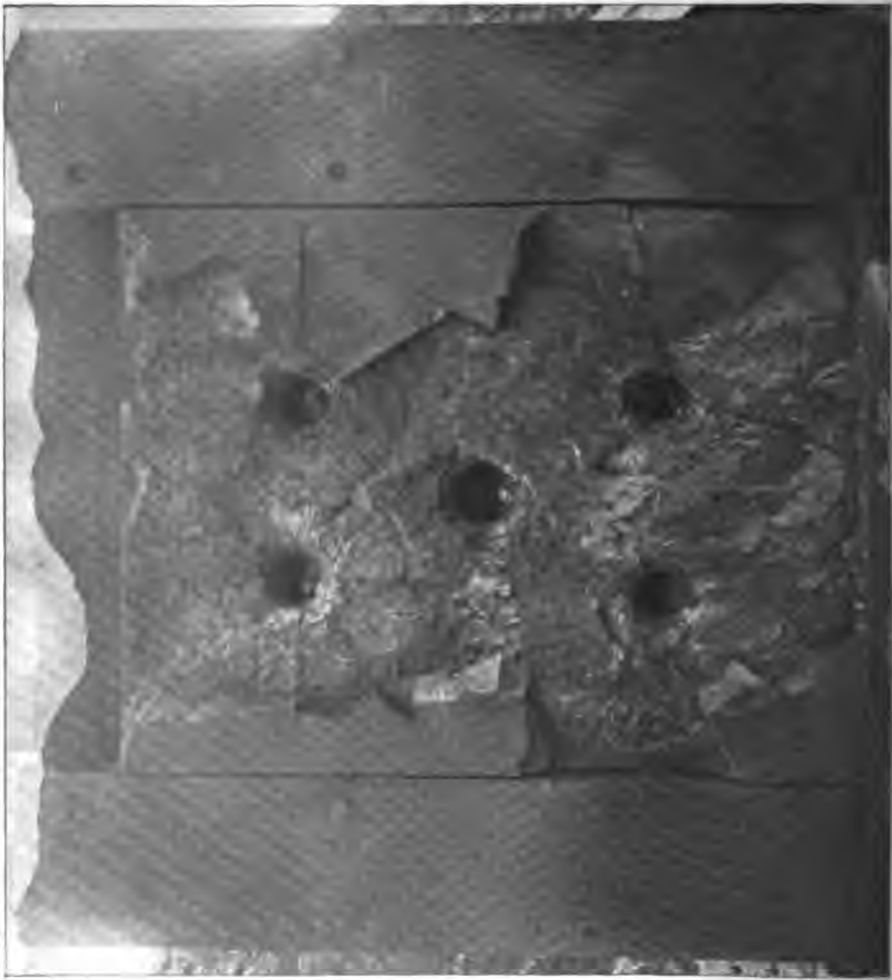
There were no cracks visible on the plate.

The side plates were uninjured and no bolts were started.

The front timber of the backing in the line of the shot hole was apparently broken in two.



NICKEL STEEL PLATE AFTER FIFTH SHOT



ROUND 15.—*Fifth shot at the compound plate.*

Gun: 8-inch B. L. R.

Projectile: Firth a. p. shell, 210 pounds. Striking velocity, 1,850 foot seconds.

Charge: 85 pounds brown prism. Striking energy, 4,988 foot tons.

The point of impact was the centre of the plate. The projectile perforated the plate and backing and disintegrated much of the metal about the hole. Most of the front plate was scaled off in twenty-four large and a great number of small pieces, the larger pieces varying in thickness from 3.75 to 5.50 inches.

Parts of the plate were left complete along each edge as shown in the photographs, but much of it separated, some of the fragments of the steel being nearly on the point of falling off. The exposed wrought-iron back showed eighteen cracks of varying length.

The metal about the interior of the hole was rough and broken. The wrought-iron surface was rough and irregular. The metal around all shot holes showed considerable disintegration. Several concentric cracks appeared in the wrought-iron back about the 8-inch shot hole.

The side plates were uninjured.

The projectile broke an irregular hole through the backing, but all damage was local.

The shell was recovered entire, having penetrated the earth backing about 15 feet. It was shortened 0.24 inch and the diameter of the bourrelet was increased 0.015 inches.

The board then adjourned until the plates could be removed from the backing so as to expose to view their rear faces.

The board met at the Naval Ordnance Proving Ground on October 10, 1890, and examined the backs of the plates and the fronts of the backing, with the following results:

BACK OF STEEL PLATE.

No. 1 shot. Back bulge 3.5 inches high and 16 inches diameter.

No. 2 shot. Back bulge 3.0 inches high and 15 inches diameter.

No. 3 shot. Back bulge 2.6 inches high and 16 inches diameter, with a piece broken out.

No. 4 shot. Back bulge 2.6 inches high and 15 inches diameter.

No. 5 shot. Back bulge 6.25 inches high and 22 inches diameter, with two pieces broken out.

Diagonal cracks from front of plate all through to back.

BACKING OF STEEL PLATE.

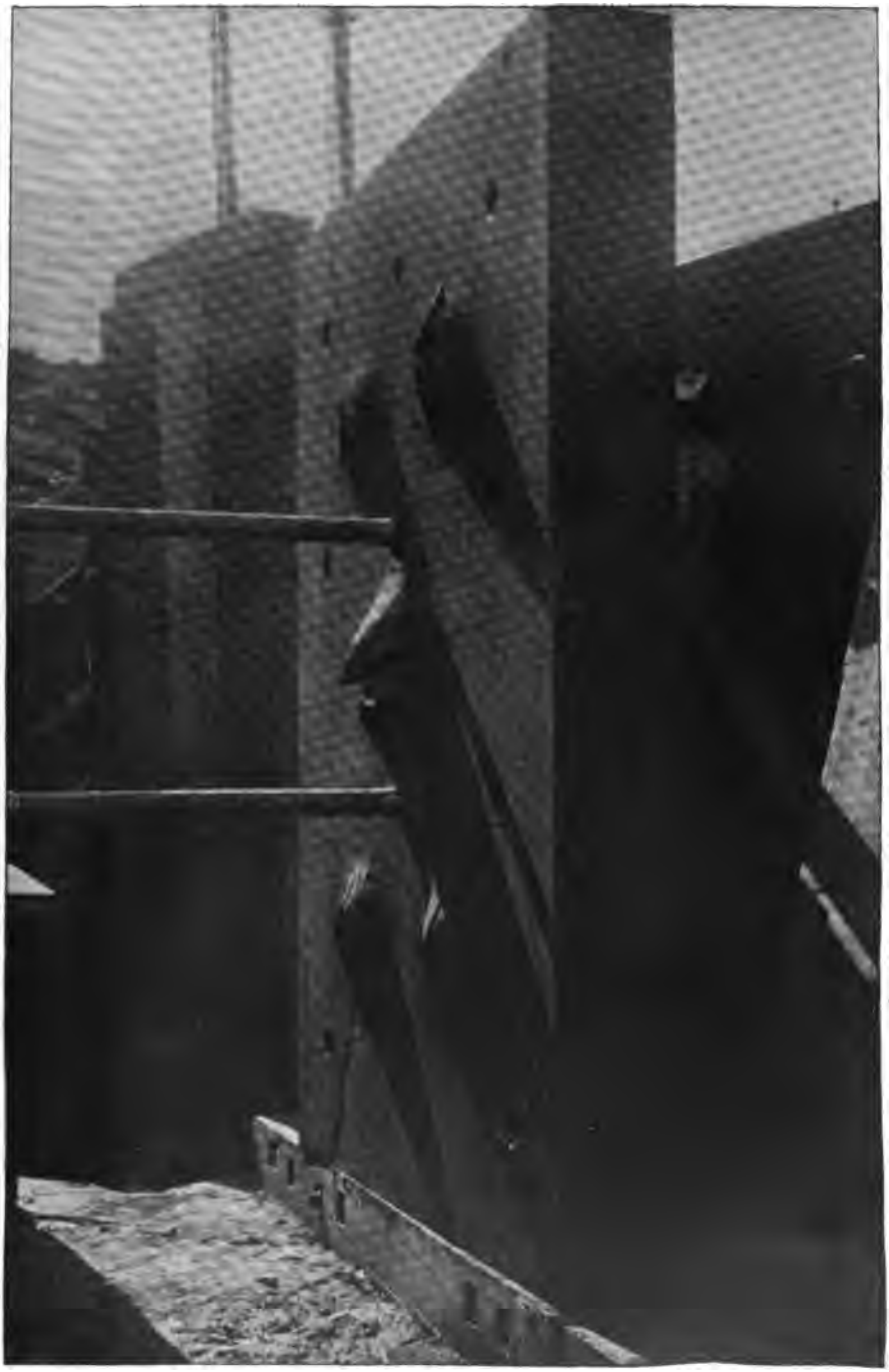
No. 1 shot. Indented 2.75 inches.

No. 2 shot. Indented 2.40 inches.

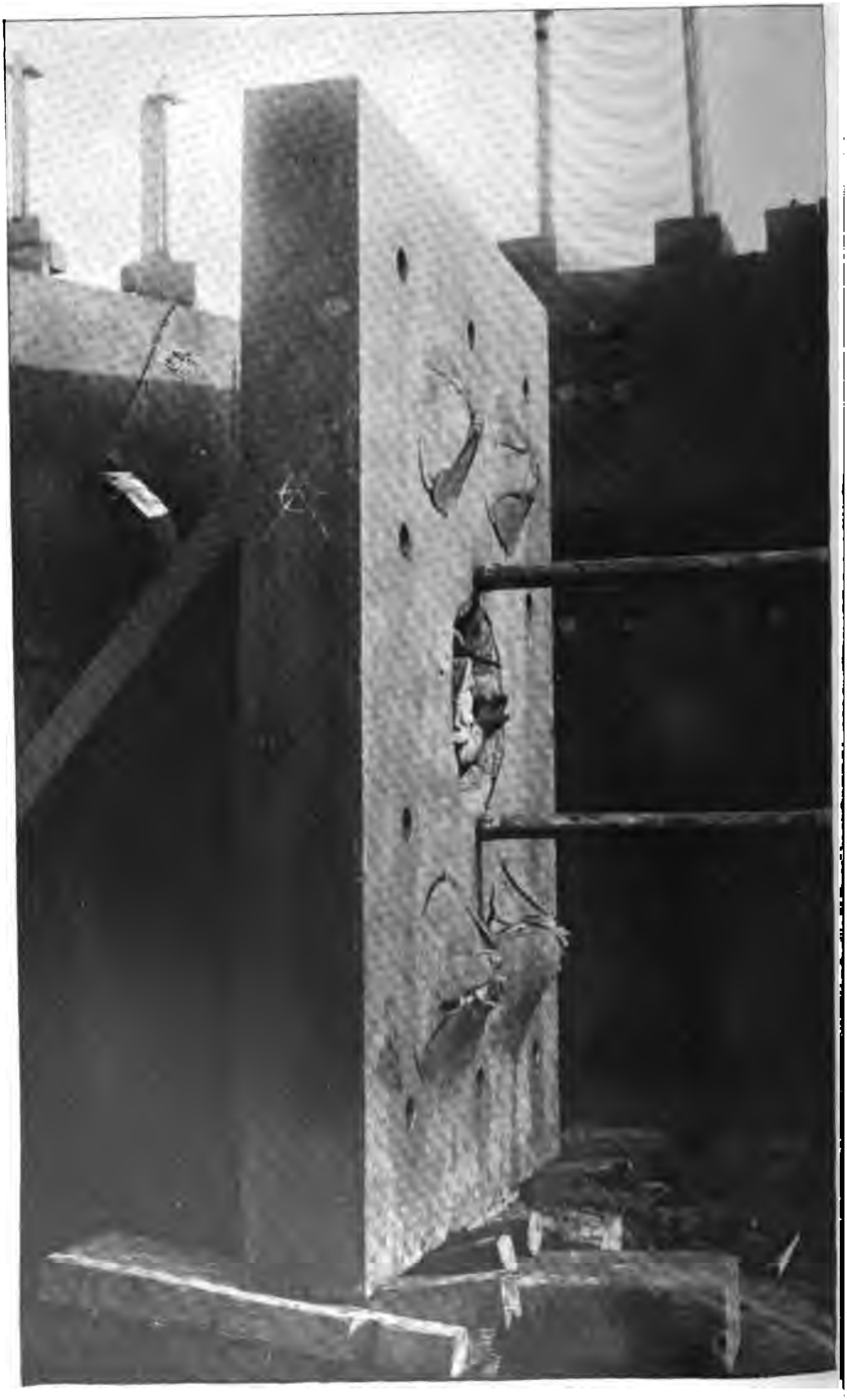
No. 3 shot. Indented 2.00 inches, two pieces embedded in backing.

No. 4 shot. Indented 2.40 inches.

No. 5 shot. Indented 5.25 inches, and one piece embedded in the hole.



BACK OF STEEL PLATE.



BACK OF NICKEL-STEEL PLATE.

BACK OF NICKEL-STEEL PLATE.

No. 1 shot. Back bulge 5 inches high and 21 inches diameter.
No. 2 shot. Back bulge 6 inches high and 21 inches diameter.
No. 3 shot. Back bulge 4 inches high and 19 inches diameter.
No. 4 shot. Back bulge 4 inches high and 18 inches diameter.
No. 5 shot. A crater in back of plate was formed of an average depth of 3.5 inches and 21 inches diameter.

BACKING OF NICKEL-STEEL PLATE.

No. 1 shot. Indented 5.25 inches.
No. 2 shot. Indented 4.75 inches.
No. 3 shot. Indented 3.50 inches.
No. 4 shot. Indented 3.50 inches.
No. 5 shot. A hole 10½ inches deep in the wood and 6 inches deep to a fragment of metal left in the backing from the crater in the plate.

BACK OF COMPOUND PLATE.

No. 1 shot. Back bulge 6.4 inches high and 20.5 inches diameter.

No. 2 shot. Back bulge 6.25 inches high and 18 inches diameter.

No. 3 shot. Back bulge 6 inches high and 20 inches diameter.

No. 4 shot. Back bulge 7.25 inches high and 19 inches diameter; a large piece of plate broken out.

No. 5 shot. Back bulge 7.5 inches high and 21 inches diameter; a piece of plate broken out.

BACKING OF COMPOUND PLATE.

No. 1 shot. Base of projectile 11 inches in from face of backing.

No. 2 shot. Base of projectile 4.75 inches in from face of backing.

No. 3 shot. Base of projectile 13.1 inches from face of backing.

No. 4 shot. Through hole: piece of plate embedded in side of hole.

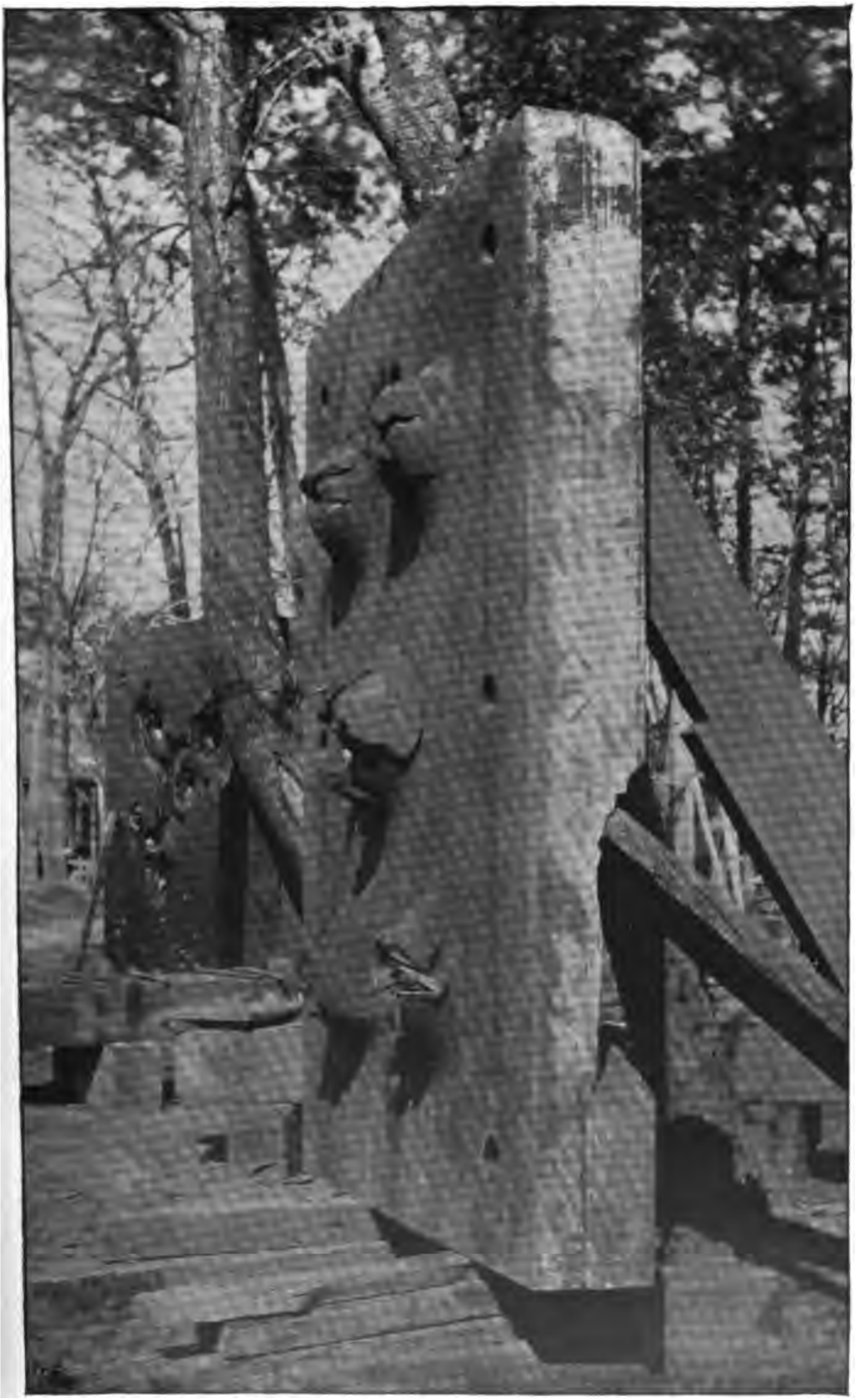
No. 5 shot. Through hole: piece of plate embedded in side of hole.

No bolts in any of the plates were injured.

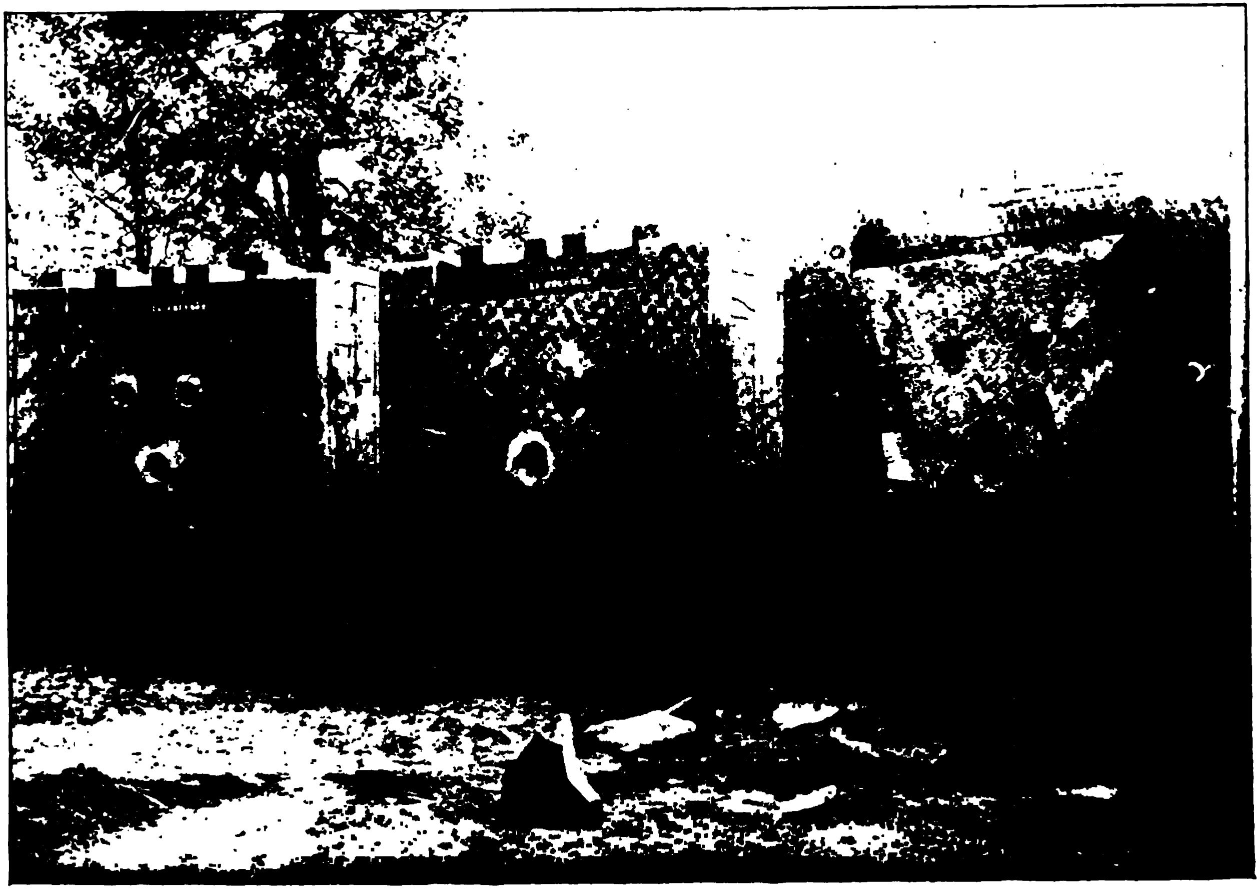
SUMMARY.

The compound plate was perforated by all projectiles, and its steel face was destroyed. Two of the shells passed completely through both plate and backing.

Both steel plates kept out all projectiles, the all-steel plate showing slightly greater resistance than the nickel steel plate, but the former was badly cracked by the 8-inch shell, while the latter remained uncracked. The board therefore places the three plates tested in the following order of "relative merit": 1. Nickel-steel. 2. All-steel. 3. Compound.



BACK OF COMPOUND PLATE.



VIEW OF PLATES AFTER FIVE SHOTS EACH.

FRAGMENTS OF COMPOUND PLATE IN POSITION IN WHICH THEY FELL.

The compound plate here tried proved so inferior in resisting power as scarcely to merit mention in comparison with the other competing plates. The business standing and reputation of its makers preclude the possibility of its having been sent as a sample of anything but their best manufacture. The hard face-plate was not only easily overcome by the projectiles but was also nearly all scaled off from the soft, wrought-iron back. Such scaling off has not been infrequent with compound plates, and clearly demonstrates the general unreliability of the weld of hard face to soft back. The ease with which all the projectiles perforated shows that the plate fell very far short of having 50 per cent. greater resisting power than a wrought-iron plate of the same thickness. Still, it was undoubtedly a much better plate than that of Trial No. 4, the one representing the armor of the *Infanta Maria Theresa.*

As was to have been expected of a good Cammell compound plate, when attacked by comparatively small projectiles, the soft wrought-iron back was uncracked at the end of the trial. This is always claimed as an advantage for the compound plate and it generally holds true, but the unfortunate fact remains that the soft plate thus left is open to perforation by even medium calibres of modern rapid-fire guns.

The effect of the larger projectile used at the fifth shot was out of all proportion to that of the 6-inch, its recovery undeformed proving that all the work was done on the plate. No such great difference, at the corresponding shots, was found with either of the two other plates. The cracking of the steel plate would, very likely, have resulted if a 6-inch projectile had been used instead of an 8 inch, although probably not to so great an extent, as, with both compound and steel plates, the liability to cracking rapidly increases with an increase in diameter of projectile, whether a. p. or chilled.

A notable feature with the compound plate in this trial was the decided disintegration of the metal at each shot, on account of which each succeeding projectile encountered less resistance, as evidenced by the successive greater penetrations.

At the end of the fourth shot at each plate a choice between the steel and nickel-steel would have been in favor of the former on account of the less amount of penetration. Up to this point the steel plate had proved itself the superior—in resistance to penetration and fracture—of any plate ever previously tested, having withstood from the finest a. p. projectiles a total energy of 11,952 f. t.—1,289 f. t. per ton of plate—with a maximum penetration beyond the back of the plate of but 2.75 inches, and without having developed a crack of any description. Three of the four projectiles remained unbroken, which, with the equal amount of penetration in each case, gave unmistakable proof of the homogeneous character of the metal of the plate. Its great elasticity was evidenced by the rebounding of the projectiles and the manner in which the metal came to the front and heaped up in regular fringes about the shot holes.

But the nickel-steel plate gained the day at the fifth shot, when, with a striking energy of 4,988 f. t., an 8-inch a. p. projectile was broken in many pieces after having forced its point but 10½ inches beyond the back, and that without developing a sign of a crack. This plate showed the same degree of homogeneity of metal as the steel one, but was tougher and more tenacious, as was evidenced by the gripping of the projectiles—a grip which was apparently not lessened by the shock of succeeding blows. It will be noticed that the metal did not come to the front in fringes as in the steel plate, but clipped off about the edges of the shot holes, instead. With most of the shots at this plate it will be seen that, unlike those at the steel plate, much of the energy was expended in breaking the projectiles. The localization of effect was very remarkable.

Never before in the history of modern armor had a plate given results to compare with these; withstanding a total energy of 16,940 f. t.—1,835 f. t. per ton of plate—without developing a single crack and without being perforated.

At the last shot at the steel plate an 8-inch a. p. projectile, with a striking energy of 4,988 f. t., succeeded in getting its point only 5.2 inches beyond the back. The plate through-cracked in two cross lines which were so serrated that when the plate was removed from its backing the parts remained firmly in place. Had this plate been on a ship's side the slight penetration and small bulging of back would probably have caused but little injury to the framing behind; and with the excellent system of bolting employed, it would still have offered an efficient protection to projectiles up to 8 inches in diameter.

In studying these two competitive trials we find that all indications go to prove that the 6-inch projectiles used at Annapolis and those used during the three last shots at each plate at Ochta were almost identical in quality, thus enabling us to make a fairly exact comparison of the resisting powers of the plates tested. The compound plate, in each case, was badly beaten, though the Cammell plate showed, for effects from identical projectiles, to better advantage than the Brown. These two, however, did so much worse than their competitors as to make it unnecessary to institute any comparison.

In the Ochta trial we know definitely that the two first projectiles were of poor quality, and, in consequence, are compelled to put them out of the question. We are thus limited to the consideration of the three last, with which the greatest energy employed was exactly sufficient, by calculation, to just perforate the steel plate, the mean energy, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, being 1.44.

At the Annapolis trial the energy of the 6-inch projectile was, by calculation, a little more than sufficient to just perforate the steel plate, being, as compared with that necessary to just perforate a wrought-iro plate of the same thickness, 1.50.

Bearing this in mind in comparing the Vicker's Ochta plate and the Annapolis steel plate of Schneider's, we see that in the former the points of the three last projectiles penetrated respectively 7, 11, and 4 inches beyond the back of the plate, while in the latter the penetrations of the four 6-inch projectiles beyond the back of the plate were respectively 2.75, 2.4, 2, and 2.4 inches, showing most conclusively the much greater power of resistance to penetration possessed by the Annapolis steel plate. Its greater resistance to fracture was evidenced by the fact that at the second shot at the Vicker's plate, and that with a softer projectile, two through cracks were developed, while the Schneider steel plate at the end of the fourth shot with 6-inch projectiles did not show a crack of any kind, although the energy per ton of plate developed had been 1,289 f. t. as compared to only 1,101 f. t. for all five shots at the Vicker's plate. The test of the latter was much less severe than that of the former, both as to penetration and fracture, but the Schneider plate withstood it very much better, stopping its projectile much more effectively notwithstanding that it came at it with a greater comparative energy.

Now as to the two nickel-steel plates. These differed somewhat in constitution, containing unequal proportions of nickel. The one tested at Ochta was made at least a year before the one tried at Annapolis, and we must admit that with this, or any other practicable alloy, such a firm as that of Schneider & Co. would, in a year's time, be apt to make considerable progress in the development of a new manufacture.

The same difference in severity of test existed with these two plates as has been described in a preceding paragraph for the two steel plates, but the difference in degree of penetration in this instance was in favor of the Ochta plate, although, with that gain, it showed a corresponding loss in its power of resistance to fracture. Could a little of the hardness of the Ochta plate have been imparted to that tried at Annapolis without taking away from its toughness, it would have made it a model plate for armor protection.

Judging from the results obtained at Ochta and Annapolis we can say that 1.44 is not below the limit of comparative energy that 10½-inch compound plates will stand before perforation when attacked by 6-inch a. p. projectiles, and that the corresponding limits for steel and nickel-steel plates are very much higher.

An information trial of a Bethlehem 11½-inch steel plate took place in January last. This plate was attacked by three Holtzer a. p. projectiles from a 6-inch B. L. R., with a striking energy of not more than 2,956 foot tons. The plate was a little too thick to be fairly judged by the action of such small projectiles, but the results, although inferior to those obtained with the steel plate at the Annapolis competitive trials, were considered very good for a first plate.

VI.

THE FIRST TRIAL OF A NICKEL-STEEL ARMOR PLATE.

The details of this trial are given to show, in connection with the Annapolis and Ochta trials, the excellent results obtained with nickel-steel from the very first.

Date of trial: July 16, 1889.

Details of plate: Dimensions, 47.2 inches long, 43.3 inches wide, and 9.33 inches thick. Eight clamps secured its edges to a backing of 31.5 inches of hard wood.

Firing details. (See Plate A.)

[Gun used, 15 centimetre (5.91 inch), 36 calibre B. L. R.]

Projectile (Holtzer a. p.)	pounds	99.2
Striking velocity	f. s.	1,971
Striking energy	f. t.	2,671
Energy as compared with that necessary to just perforate a wrought-iron plate of the same thickness		1.61

One shot only was fired. The projectile struck the centre of face of plate, penetrated 15¾ inches, and remained in the plate. No cracks.

VII.

THE ARMOR BEST ADAPTED TO NAVAL USE.

Before summing up the respective merits of the types of armor herein considered, it will be well to see if we can form some idea of what functions ships' armor will be called upon to perform in war service; and also, if the methods employed in the trials described have been such as to give an adequate idea of the value of the plates tested for armor protection.

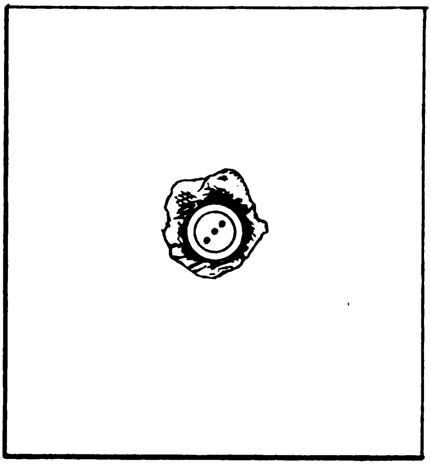
Armor is employed to protect the working and fighting materiel and the personnel behind it from the destructive effects of an enemy's projectiles, and its value depends directly on its power to keep out these projectiles for a maximum period of time. This power is the resultant of two factors—resistance to penetration, and resistance to fracture—and in referring to these hereafter it will be understood that each plate has a corresponding projectile, the service striking velocity of which, at fighting range, is sufficient to enable it to do no more than just get its point through the plate.

The results of all late armor trials, except those of the nickel-steel plate at Annapolis, show that armor always yields by penetration, accompanied by more or less shattering.

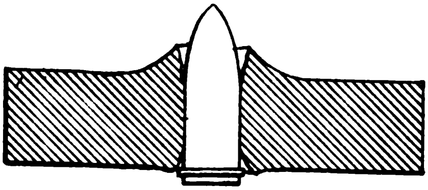
If a plate, while resisting penetration from its corresponding projectile, submits to such fracture as to cause it to fall off wholly or in part from the place it is intended to protect, its value for armor protection is not worth considering.

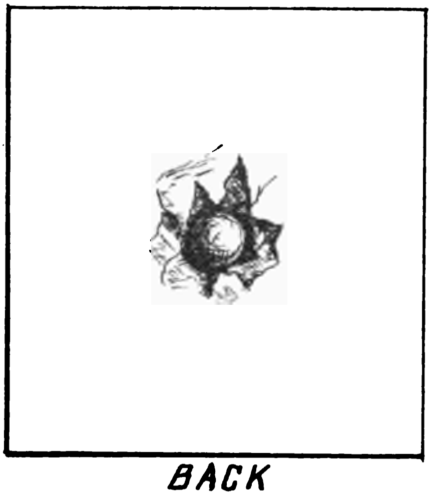
PLATE A.

FIRST TEST OF A NICKEL-STEEL PLATE



FRONT





BACK

The weight of present naval opinion is that in future actions the element of time will not permit of making a special effort for shattering or racking effects, but that instead, every effort will be made to insure perforation by projectiles filled with some powerful high explosive. The terrible results of the explosion of such a projectile within a ship's sides can not be overestimated, it being very possible for one only to practically put a ship out of action. Of course, any amount of cracking of plate, provided the broken parts remain in place, will be preferable to such a catastrophe.

That this is not an unlikely contingency for the future is evidenced by the fact that such projectiles have already been sent through 5-inch steel plates. Hence, supposing a reliable delayed-action fuze devised, we will have but one important condition to seek for in our ships' armor—that of successful resistance to perforation, even at the expense of any amount of cracking, provided only that fractured parts be kept in place.

Report has it that more than one nation is already in possession of a reliable delayed-action fuze, and Mr. W. H. White, the English Chief Constructor, has publicly stated that such fuzes are no longer a matter of theory, but that they have been actually developed, and that high explosives can be carried through 6 inches of armor.

The conditions in armor trials only approximate to what may be expected in action. At sea the chances in favor of the plate will be increased considerably at point blank range on account of the unsteadiness of gun platform and target and the less likelihood of hitting normally, and these chances will become greater as the range increases. The chances in favor of high-power guns will be correspondingly diminished, but we can not say that this will prove true of the armor piercing calibres of rapid-fire guns at ranges up to 1,000 yards—one-half mile. When we consider that the service muzzle velocities of these rapid-fire guns will not be less than 2,500 f. s., and that they have a rate of six unaimed shots a minute, it seems reasonable to suppose that, within the above range, one or more plates of an enemy's ship may receive nearly as severe punishment, within a similar area, as was inflicted on the plates at Ochta and Annapolis.

In view of an almost entire lack of experience in naval warfare under modern conditions, it is impossible to make the above statement with certainty, but we can assert that results attained in naval actions in the past, under conditions decidedly more unfavorable to the attack, will be better in the future, when higher velocities, flatter trajectories, and a greatly increased rapidity of fire will be the rule, and pointing will be unobscured by smoke.

During our late civil war, in the attacks on Charleston and Fort Fisher, from two to four shots struck frequently within a space of not more than the area of either the Annapolis or Ochta plates. Of such examples the most notable took effect on the *Canonicus*, *Passaic*, *Wee-*

hawken, *Nantucket*, *Nahant*, and *New Ironsides*. In 30 minutes the *Keokuk* was struck ninety times. The ram *Tennessee*, in Mobile Bay, received not less than nine shots within the space of a few square feet and her smokestack was absolutely riddled. Other examples could be furnished, but these are sufficient to show that, in the past, one or more sections of similar area have received almost as many shots as did the Annapolis and Ochta plates.

In these examples the ranges were all short—within 1,000 yards—and the fighting in comparatively smooth water, but the teachings of history are to the effect that naval commanders generally seek close quarters, and no one will assert that no future naval actions will be fought in comparatively smooth water. Even at long range the modern gun will be likely to get in a fairly good proportion of hits, for at ranges varying from 1,400 to 1,600 yards, H. M. S. *Colossus*, steaming at a speed of 8 knots, got in three hits out of four shots fired from her two forward turret 45-ton guns at a target 15 feet high by 40 feet long; and about five years ago, in an exercise attack on the French ironclad *Armide* by a French squadron, at ranges varying from 3,281 up to 5,280 yards in a comparatively smooth sea and with a light haze, one hundred and forty shots were known to have hit the *Armide* out of six hundred and fifteen fired from guns—many of old types—of not less than 5.5 inches calibre. We believe that with the number of large rapid-fire guns which will appear on all future vessels, and with their rapidity of practically unaimed fire up to a range of nearly 1,500 yards—three-quarters of a mile—the present method of testing plates of not more than 10½ inches thickness with 6-inch projectiles seems eminently proper. But it must not be inferred from this that we consider 10½ inches the maximum thickness to which we should pay attention. Such plates are thin as compared to those which will be used to protect battle ships, and thicker plates attacked by larger projectiles should receive most attention.

Unfortunately, late trials of thick plates are exceptional, and we are compelled to judge of the value of all thicknesses of armor by the effects of small projectiles on comparatively thin plates, although it is well known that small projectiles do not test the tendency of a plate to fracture; that all systems of armor suffer most from fracture when attacked by projectiles of large size.

But, as the lack of necessary experience renders all this conjectural, we must, in seeking for the best type of armor protection, consider that perforation by a single projectile containing a charge of some powerful high explosive, and its explosion within a ship, would cause such great and general destruction that no effort should be spared to prevent it.

Such a projectile, to carry a large charge of high explosive, must have comparatively thin walls, and hence it is not possible to give it all the qualities of an a. p. projectile, but it is sufficient for the naval officer to know that, as full advantage will probably be taken of the high explosive shell in the future, the armor which at proof trial will keep out an a. p. projectile of the same calibre will give adequate protection against the high explosive. Reasoning thus, we have now to determine which one of the types of armor herein discussed will best resist penetration without falling from its backing.

COMPOUND ARMOR.

The results of the trials herein described and discussed prove that compound armor will not satisfy this condition. With medium quality projectiles of small calibre, such as the English Palliser, the hard steel face of the compound plate holds up to its work well and answers all purposes; but at the present time a. p. projectiles of excellent quality and high velocities are the rule, and against such the hard steel face of the compound is invariably overcome.

Many instances go to show that the weld of hard steel face to soft wrought-iron back is not reliable, and when, as at the Annapolis trials, the hard steel face is shaken off, the soft back remaining, even if not previously fractured, would not offer sufficient resistance to prevent perforation even by common shell.

The lack of homogeneity of metal of which compound plates are composed is very noticeable in the trials herein detailed. This is a fault inherent to the mode of manufacture which becomes more pronounced with thicker plates.

Unless rigidly backed, which could not be the case when fitted to a ship, the compound plate is very apt to give or bend on impact, and this, in addition to the large amount of back bulging, would so damage the framing behind the plate as to render repairing necessary before a new plate could replace an injured one. The system of bolting is limited by the character of the back, which, being soft, will not permit of the use of a large number of small bolts, but will only take a small number of large ones. This is a great disadvantage, as it renders possible, in the event of fracture—which will be almost a certainty with both steel and compound armor when attacked by good projectiles of relatively large calibre—the falling off of broken parts.

The face and back being of entirely different metals the plate is apt to be weakened when bent to the curve of the part of the ship to which it is intended to be fitted. This would have been practically demonstrated long ago if the tests for turret armor had been conducted against proof plates representing the form of section of turret for which intended.

From these facts we think that any unprejudiced mind will admit that compound plates (hard steel face and wrought-iron back) will not satisfy the essential condition demanded of ships' armor, *i. e.*, furnish adequate protection to the vulnerable parts behind it.

STEEL ARMOR.

The value of steel for armor protection can be best demonstrated by comparing it with the compound metal. With steel plates the face is hardened, but not to the same degree as the face of the compound. This disadvantage, however, even in plates of medium thickness, is more than compensated for by the relatively greater hardness of the back, which tells more and more in favor of the steel as the plates increase in thickness. The softer face permits of easier penetration at first, but the relatively greater hardness of back enables the plate to offer a more uniform and greater total resistance. In other words, its resisting power to penetration depends on its qualities as a mass rather than on the hardness of its surface, and in consequence, it will show to better advantage the greater its thickness.

As a result of the softer face, projectiles of medium quality, although broken up by both metals, obtain a greater penetration in steel than in compound, as is evidenced by the French trials, but with a. p. projectiles, the resistance of the steel depending on its mass, penetration is less than in compound, where, the hard face once overcome, the resistance of the soft back to penetration is but slight.

Then, again, the steel is more homogeneous than the compound and must be preferred on account of its greater uniformity and consequent ability to be cast in shapes in which compound can not. This is clearly demonstrated in the trials considered and has been so thoroughly proved, after years of exhaustive experiments conducted by the justly noted Gavre Commission, as to lead that body to use steel plates only for the reception tests of projectiles for the French navy.

These armor trials have also demonstrated that steel possesses a much greater degree of toughness and elasticity than compound metal. This is a decided advantage, inasmuch as it causes the projectile energy imparted to a plate to be distributed through a greater mass, thus enabling it to depend less on its backing for support, preventing yielding at point of impact, and rendering serious damage to the framing behind it less possible. The increased hardness of back permits the use of a greater number of bolts, thus lessening the liability to falling off of fractured parts.

However, with all these advantages, steel possesses one inherent defect—the liability to through cracking. This is a prominent feature in all armor trials, but it seems to exert but little influence on penetration.

If this through cracking causes the falling off of the fractured parts, either from succeeding shots or from the motion of the vessel in a seaway, steel would be useless for armor protection, but a careful study of armor trials is conclusive in showing that the system of bolting employed will hold fractured parts in place unless the plate is terribly fractured by a greater number of blows than we can conceive of its receiving. This was well exemplified in the Ochta trials, where the corners of the Schneider plate, although completely cracked away, were well held in place by their bolts. It must also be remembered that when fitted to a vessel each plate will receive additional support from the plates surrounding it.

A noticeable feature in steel plate trials is the peculiar serrated form of the cracks, as compared to the straight or curved lines of cracks in compound. This enables fractured parts to so dovetail into each other as to cause them to remain in place even when unsupported by surrounding plates.

It is evident that when badly cracked the separated parts of steel plates will offer considerable resistance to penetration. In the Annapolis trials, at the end of the fifth round of shots, each of the four separate parts of the steel plate would still have resisted another projectile, while the compound plate, which presented a thickness of less than 7 inches of wrought-iron, would have been open to perforation by projectiles from as small a rapid-fire gun as the Hotchkiss 14-pounder. Of course, it can not be believed that modern projectiles could be kept out of a ship armored with such plates.

As any amount of cracking is preferable to perforation, we consider that for ships' armor steel is incomparably superior to compound on account of greater uniformity in quality of metal; ability to be manufactured in curved forms; ability to take such bolting as to be retained in place after fracture; less liability to cause damage to framing behind it on impact of projectiles, which means less cost and trouble in replacing injured plates; and greater absolute protection to a ship on account of greater resistance to projectiles for a corresponding thickness.

NICKEL-STEEL ARMOR.

Our experience with nickel-steel is quite limited and we must judge of its merits from the results of but few trials. Fortunately, however, two of these trials were in competition with steel and compound plates, and the results obtained in these, and also in others of which we are not at liberty to give details, were uniformly excellent. In addition to the plates of this metal herein described it is definitely known that quite a large number of 4-inch protective deck plates have successfully undergone severe tests in England. Of one of these Sir James Kitson, at the International Meeting of Iron and Steel Men, stated that "nickel-steel armor plates have been manufactured, and tested by Admiralty officials, giving results which rank about 75 per cent. above any similar plates ever tested in England," a statement which we have reason to believe was not at all exaggerated. In addition to this we can state that many eminent metallurgists agree that an alloy of a certain proportion of nickel with steel is advantageous to steel when used for armor plates, in that it renders it thoroughly homogeneous and increases its strength and tenacity, imparting hardness without decreasing its toughness. Many experiments have proved that it stands punching very well without cracking; that it can be worked and hammered; and that it can be cast into shapes without difficulty. In other words, that it is homogeneous, tenacious, malleable, and temperable.

As far as resistance to penetration is concerned, no steel or compound plate has ever equaled the nickel-steel plate tested at Ochta, which, even at the end of the trial, was able to give better protection than either of its competitors. It proved its ability to keep out the projectiles and at the same time to remain attached to its backing.

The Annapolis nickel-steel plate did not possess the hardness of that at Ochta, but it showed a tenacity never before evidenced by any plate, and that with an absence of brittleness which enabled it to withstand its tremendous punishment without a crack of any description. Taking everything into consideration it proved the superior of any plate ever previously tried, and better qualified for protection than any known type of armor. It showed less liability than ever before noticed in any plate to a fault common to all other types of armor; *i. e.*, the liability to be broken up by continuous fire.

Many foreign journals have stated that the nickel-steel is very injuriously affected by frost, but we can state that a trial at Annapolis fairly disproved this. The same nickel-steel plate tested at the Annapolis trials was subjected to two more shots from a. p. projectiles under similar conditions to those at the competitive trials, the last one with the plate cooled to a temperature of 28° F. The penetrations were about the same as those obtained in the Annapolis trials and were accompanied by some cracking, but there was nothing to indicate any particular brittleness of plate due to the low temperature. Metallurgists and armor-makers can not but admit that all armor metals have some increase of brittleness when cold, but there is no reason to believe that this increase is greater with nickel-steel than with any other.

If future trials of nickel-steel plates give results as good as those obtained in the past, it will be proof positive of the decided superiority of this metal for armor protection over compound and steel.

The naval officer will be satisfied when he is protected by the best armor extant, but the metallurgist and armor-maker, being mainly interested in the development of the plate, will not remain satisfied with anything short of the practically unattainable—the plate that will successfully resist both penetration and fracture.

The principle upon which compound armor is based—a hard projectile-breaking face and a graduated resisting back—is a good one, but the manner in which it has been carried out in the English compound plate is radically bad.

Great efforts must and will be made to harden the face of the plate to resist and break up projectiles, and if this principle can be successfully applied to nickel-steel plates of as good quality as those described in this article we believe that it will result in giving us the desideratum in armor—an effective protection for ships.

Several methods for applying this principle to armor plates, by processes resulting in superficial carbonization, have been devised, and as a fitting termination to this article, we will give some details of late trials at Annapolis of plates treated by one of these processes, that of Mr. H. A. Harvey. Each of the plates tried was treated with the design of transforming its surface into a high grade of very hard steel, without causing its back to lose its original toughness, and without producing a pronounced plane of demarcation between the two qualities of metal, such as is the case in the weld of the English compound plate.

Trial of an untreated Schneider steel plate, after having been treated by the Harvey process.

Date of trial: February 14, 1891.

Details of plate: A Schneider untempered steel plate, 8 feet by 6 feet by 10¼ inches, treated by the Harvey process of superficial carbonization.

Backing: Same as that used at Annapolis competitive trials.

In treatment by the Harvey process, the plate became warped in the form of a section of a sphere of slight curvature, such that the distance from rear face of plate at its center to chords connecting diagonal corners was 3 inches.

Ballistical details.

[Gun, 6-inch, 35 calibre, B. L. R.]

Projectile	pounds	100
Striking velocity	f. s.	2,065
Striking energy	f. t.	2,956
Temperature	deg. F.	40
Range	feet	263
Energy as compared with that necessary to perforate a wrought-iron plate of same thickness		1.47
Angle of plate with normal to line of fire		13° 22′

Firing details. (See Plate B.)

Round 1. (Holtzer a. p. projectile).—Point of impact, 2 feet from right edge, 23 inches from top. Projectile penetrated not more than 4 inches, and broke up into very small fragments. A portion of the head remained in the plate so welded to the metal of the plate that when it was knocked out by subsequent shocks of impact, it carried portions of the plate with it. No front bulge or fringe. Diameter of shot hole at face, 9 to 9½ inches. Two connected through cracks.

Round 2. (Holtzer a. p. projectile).—Point of impact, 2 feet from top and 23 inches from left edge. Projectile acted exactly as in Round 1, but penetration was judged to be about one-half inch greater. Portion of base recovered. Through cracks at *b* and *b′*. Partially through cracks at *c* and *c′*. No front bulge; no fringe.

Round 3. (Carpenter a. p. projectile).—Point of impact, 2 feet from bottom, 23 inches from left edge. Projectile penetrated 4 inches and broke up badly, not welding to metal of plate as two previously fired projectiles did. About same amount of base recovered as in previous round. Diameter of hole at face, 9 to 9½ inches. Very slight fringe about small portions of shot hole. Two through cracks *d* and *d′*, and one surface crack *d″*. Crack *c′* extended entirely through plate.

Round 4. (Carpenter a. p. projectile).—Point of impact, 2 feet from bottom, 2 feet from right edge. It was judged that projectile penetrated somewhat less than 4 inches and broke up badly. About same amount of base recovered as in two previous rounds. The head of the projectile was so welded to metal of plate as to make it impossible to accurately determine the depth of penetration. No bulge; no fringe. Diameter about shot hole at face, 9 to 9½ inches. Four fine, but apparently through cracks. Crack *c′* widened. Through crack *d′* extended to bottom edge of plate.

Round 5. (Holtzer a. p. projectile).—Point of impact, 1½ inches above and to left of centre of face. Projectile broke up. Head penetrated and apparently remained entire in plate. End of powder chamber 7⅜ inches beyond face of plate. This would bring the point 14.8 inches beyond face of plate (4.3 inches beyond rear face.) The greater part of base picked up near target. Diameter of hole at face of plate, 7⅜ inches, decreasing to 6½ inches at 3 inches from face. No fringe. More scaling around hole than in previous rounds. Small portions of the plate, about one-eighth of an inch thick, flaked off about 8 inches from hole. Through crack to No. 2 shot hole. Through crack to No. 4 shot hole. Three short surface cracks. Cracks made by previous rounds widened.

Round 6. (Carpenter a. p. projectile).—Point of impact, 1½ inches above and 13 inches to right of centre of face. Projectile broke up badly. Character of hole made much the same as in four first rounds, but depth of penetration judged to have been less. Through crack to No. 5 shot hole. Partially through crack extending up to the crack running down from No. 1 shot hole. Six short radial cracks. Previous cracks much opened.

This process had never before been applied to a plate of more than 6 inches in thickness.

The warping is considered to have been due to faulty conditions in applying the treatment.

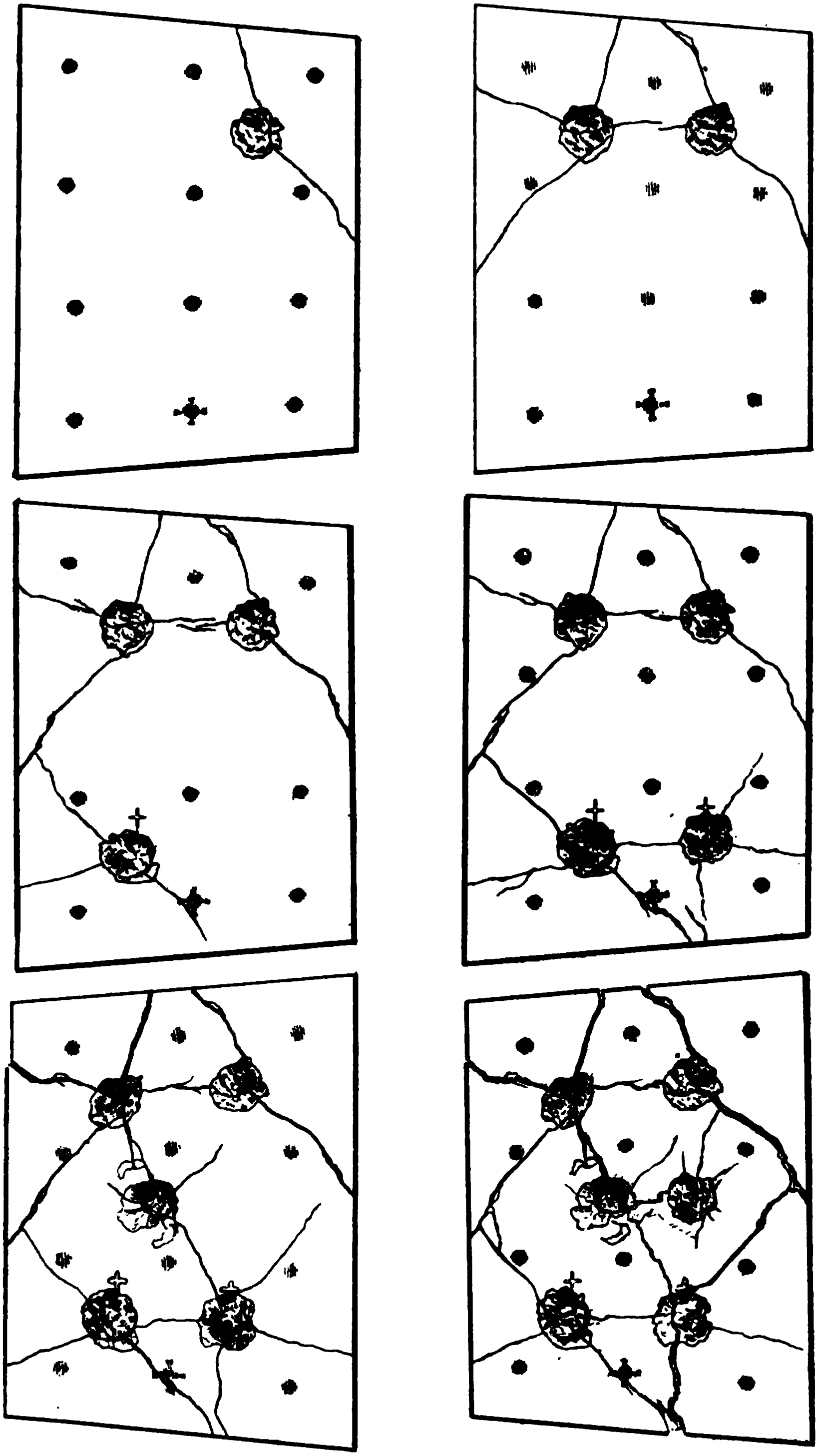
The local weakness developed at the fifth shot, and the peculiar flaking of the face, are attributed by the manufacturers to blistering, which is supposed to have prevented the effects of the treatment from penetrating to the same depth as in the remainder of the plate.

It was evident that no definite line of demarcation had been produced between the treated face and the back of the plate, and that the system of bolting employed was all that could be desired.

During the month of May of this year, five 3-inch, 8 by 6 feet plates

PLATE B.

SCHNEIDER PLATE TREATED BY HARVEY PROCESS



were tested at Annapolis: one of all steel; one of steel treated by the Harvey process; two of nickel-steel, one of which contained a higher percentage of both carbon and nickel than the other; and one of a high carbon nickel-steel treated by the Harvey process.

Under ordinary circumstances we would not consider the trials of such thin plates, but the one last named gave such phenomenal results as, in connection with those obtained in the preceding detailed trial, to lead to the belief that a successful surface-hardening process has actually been obtained.

These plates were the first ever manufactured by Carnegie, Phipps & Co., and were attacked by a Hotchkiss 6-pounder rapid-fire gun with steel a. p. projectiles having a striking velocity of 1,804 f. s. The striking energy employed, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, was about 1.71.

Ten shots only were fired at the all-steel plate, at the end of which the plate was practically wrecked.

Twenty-one shots were fired at the low carbon nickel-steel plate. A number of the projectiles perforated, the remainder rebounding broken after considerable penetration. Plate not cracked.

Twenty shots were fired at the Harvey treated steel plate. None of the projectiles penetrated more than 2 inches, but the plate was much cracked, and was broken into four pieces.

Twenty-one shots were fired at the high carbon nickel-steel plate. The plate was neither perforated nor cracked. One projectile penetrated far enough to raise a bulge on the back of the plate, while the others all rebounded broken after slight penetration.

Twenty-one shots were fired at the Harvey treated nickel-steel plate, and the results obtained were wonderful. Only three of the projectiles penetrated more than half an inch, and all of the projectiles were smashed, disappearing in small fragments. A single crack, which did not extend to an edge of the plate, was developed at the twelfth shot. This crack was slightly extended by one of the succeeding shots.

These results give additional proof of the homogeneity, toughness, and elasticity imparted to steel by nickel, and demonstrate the possibilities of the Harvey process.

In conclusion, we feel safe in stating that the Harvey, or some equally effective, surface-hardening process is a step toward the realization of the manifest advantages of a compound system of armor, which previous processes have failed to supply; and, in assuming that if nickel-steel is successfully treated by some such process, it will undoubtedly surpass both compound and steel armor as a protection for war vessels.

VII.

THE COAST-DEFENSE SYSTEMS OF EUROPE.

By Lieut. CHARLES C. ROGERS, U. S. Navy.

The Naval Reserve and the Coast Defense systems of the leading powers form the subjects of the first chapter of General Information Series No. VII; the latter system, however, was described in outline only, the intention having been, apparently, to show the connection of the former and principal subject with it.

The aim of the following paper is to describe the Coast Defense Systems of Europe in detail, where practicable, and especially with reference to organization and administration. The question of personnel has been so fully discussed in the preceding number as to leave but little room for further treatment here, and where mentioned the intention is to note changes in methods of recruiting since 1888, or for the sake of a continuity that is necessary to a full understanding of the system at hand. With the latter idea in view, a substantial repetition, also, of a few paragraphs concerning the Naval Reserves has been made where required.

In the compilation of this paper the latest available information is given; foreign official documents, reports of United States naval officers, and authentic articles in current literature have been used freely.

In studying the question of coast defense, the fact is forcibly presented that most foreign governments recognize it to be purely naval, as in all its branches, whatever the geographical condition, its function is to fight the enemy afloat; not necessarily on the high sea alone, but in all harbors, roadsteads, or other indentations of coast line, the naval element thus constituting the inner as well as the outer line of defense with respect to an attack from the sea. They have thus placed it on a naval basis; and, regarding it as a naval organization, their belief is that it should be governed by naval men and recruited from naval levies.

Reference is also made to the fact that a concensus of opinion exists abroad among military experts in both Army and Navy concerning its naval character.

GERMANY.

The scope of naval superintendence in the coast defense of Germany was defined by the Emperor's Decree of March, 1884:

> It is the expressed will of His Majesty, the Emperor, with regard to the coast defense, that hereafter the Navy is to be intrusted not only with the defense of the two great dockyards, but also with the maritime defense of Prussian fortresses on the coast and seaports. It is considered that for a thorough defense the Army and the Navy should work together according to clearly laid down rules, and to the Navy should be given supreme control of all maritime operations. From this time forward all harbor entrances must be in a condition to be immediately protected by mines and troops. Heretofore all this work having been intrusted to the Army, the engineers during the operation of mobilization were overburdened. In the future, however, the Navy, through its interest and technical skill, can readily keep harbors and channels open for the passage of friendly vessels up to the last moment and close them quickly and certainly when necessary. Again, the introduction of torpedoes proper into the cadre of army weapons reduces the general efficiency of the service, as has been shown in operations with mines. The army commandant of a coast place would find it difficult to properly control the naval personnel which in any case is necessary for the service, and he could but illy superintend the movements of torpedo flotillas. Finally, in order to establish communications with the naval outposts, extra steamers under army control would be necessary, which would complicate the service. Requisitions for merchant vessels and materials could not be wisely filled under army superintendence, and a harbor once blocked by mines, all movements, no matter how urgent, of naval vessels could only be undertaken after arriving at a special understanding between the Army and the Navy.

Naturally the Navy has a great interest in keeping open as long as possible ports which, in case of need, would serve as places of shelter, and therefore must desire that the obstacles to the ports shall be disposed in such a manner as to delay the entry and exit of its own ships as little as possible. Moreover, no commandant of a maritime stronghold can do without a seafaring personnel, who are well qualified to recognize an enemy's ships, and to keep watch on their movements. In order to afford proper aid to torpedo boats, to take advantage of their successes and to keep the enemy away—in short to carry out efficiently the duties of advance guards at sea—the defense must be furnished with vessels; and these vessels can not do without a crew who have received proper training. Consequently it is held in Germany that the equipment of coast strongholds must consist of naval forces, both in personnel and material.

When the Army and the Navy act in this manner, by affording assistance to each other, the defense of the coast gains in security, the Army is free from a charge which embarrasses it, and the interests of the Navy are felt on all points of the coast.

The seacoast defenses, fortifications, torpedo boats, torpedoes, submarine mines, etc., are therefore in charge of the Navy; and the Naval Budgets provide for the expense of maintaining torpedoes, torpedo boats, and submarine mines, and of the necessary personnel to manipulate them.

The forts at the mouth of the Elbe, in addition to those at Kiel and

Wilhelmshafen, have been transferred to the Navy; as have, also, those at the mouth of the lower Weser. They are garrisoned by the Naval Artillery, whose battalions are officered by line officers of the Navy, the noncommissioned officers being seamen gunners. Three-fourths of the privates are gunners from the Navy and the rest are recruited from the neighboring conscription district.

The transfer of the fortifications from the Army to the Navy was made on the recommendation of the Minister of War, approved by the Chief of the General Staff and the Military Cabinet of the Emperor, the reasons urged being as follows:

(1) The guns and carriages are similar to those used in the Navy.

(2) As this defense is chiefly against attack by ships and naval landing parties, seamen will appreciate more readily the points of weakness and the objects of manœuvres by ships, and will recognize the probable designs of the enemy from his preparations.

(3) As the defenses consist largely of turrets moved by steam or hydraulic power, a class of men which does not exist in the Army is necessary for the manipulation of the machinery.

(4) Seamen are better fitted to take care of works situated at the mouths of rivers and will coöperate more advantageously with the submarine defense.

Similar reasons were advanced for the transfer of all submarine defenses from the Engineer Corps of the Army to the hands of the Navy.

An Imperial Order of March 16, 1886, prescribes the duties of the board of inspection for torpedo affairs of the Navy; and all defenses of ports and harbors are arranged with the approval of the Ministry of Marine.

The submarine defense, as now organized, distributes the available torpedo boats to the several districts of the coast, each of which has a torpedo depot; the amount of torpedo armament depends on the extent, importance, and vulnerability of the district.

The garrisons of ports at the principal stations include a torpedo company, recruited from the fleet and the maritime population in the proportions provided for the Naval Artillery; such a company is also provided for forts at less important points of the coast if a necessity exists for extensive submarine defense.

The plans, designs, and manufacture of all torpedoes is consequently now under the control of the Navy. Planting and removing mines is principally boat work and that seamen perform this duty better than soldiers is shown by the improvement in the exercises and is now admitted by both services.

The accomplishment of such a change in a country where the influence of the Army is almost supreme indicates that the benefits to be derived were considered sufficient to overcome all prejudices of corps.

GENERAL SYSTEM OF DEFENSE.

The harbors of Kiel and Wilhelmshafen are each placed under the control of a Vice-Admiral, whose title is Chief of the Station. These posts are practically analogous to those of the Naval Prefects in France. The Baltic littoral and the waters belonging to it, which are separated from the North Sea by the peninsula of Jutland, belong to the Kiel district. The coast of the North Sea is intrusted to the Chief of the Station of Wilhelmshafen. The whole defense of the German coast is therefore directed by these two Chiefs of Station. Their duties include the supervision and the instruction of the personnel; they have to provide for rapid mobilization and look after all stores.

When Germany first began the development of her naval resources, after her successful wars against Denmark, Austria, and France, it was difficult to procure the crews necessary for the fleet, and the coast forts continued to be garrisoned by the Marine Artillery, which formed part of the Army. This special corps in 1875 numbered 1 staff officer, 13 subalterns, 46 officers, and 412 men. When the Navy became stronger and torpedo boats were introduced into coast defense, it was seen that the Marine Artillery was no longer capable of performing its task; it was therefore dissolved in 1877 and the Naval Artillery was formed. This body serves the coast artillery, the torpedo batteries, and the mines. It consists of three divisions, the first stationed at Freidrichsort, the second at Wilhelmshafen, and the third at Lehe. Each division is composed of three companies. The chiefs of divisions are lieutenant-commanders, who are assisted by a lieutenant as adjutant and by a paymaster. The company officers consist of a lieutenant as chief, of a sublieutenant and ensign. The chiefs of divisions serve for 5 years, the captains of companies for 3, and the junior officers for 1 and 2 years. The Chief of the Station at Wilhelmshafen is the commander of the fortress, while the forts of Friedrichsort are under commanders subordinate to the Chief of the Station. In the forts at the mouth of the Weser, at Geestemunde, and at Cuxhaven, the Senior Naval Officer is commander.

The men are drafted under the same rules as the Army and much depends on physical condition for assignment to this corps. The standard for admission is as high as that for the Prussian Guard, large, strong men being especially required and selected. As a rule they do not serve on board ship, being primarily intended for service in the coast fortifications. In case of necessity they may, however, be assigned to armored vessels as gunners. The noncommissioned officers are selected from sailors of long experience.

The uniforms and drills are naval, seamanship alone being excepted from the latter. The Naval Artillery is an especially fine body of men.

Two torpedo divisions were established in October, 1887, one at Kiel and another at Wilhelmshafen. They comprise the entire force for the torpedo-boat squadrons. It has been found necessary to specialize this force as much as possible by training sailors and firemen for torpedoboat service only.

Under the Chief of the Station is the Marine Inspector, who has the rank of Rear-Admiral or Captain. Under his control are the naval division, the artillery training ship, the mine training ship, the mine and artillery depots, the noncommissioned officers of artillery, the torpedo divisions, and the ships in the First Reserve. To the depots are attached the artillery and the torpedo officers, who are taken from the noncommissioned officers, and are promoted as high as the rank of captain-lieutenant, but can not be detailed for service on board ship.

The Inspector's chief duty is to see that all documents relating to mobilization are correct and not out of date. He has to keep himself informed of the exact condition of the coast fortifications, to inspect the men under him as often as may be needful, and the artillery and mine depots at least once a year. After each inspection a report has to be sent to the Chief of the Admiralty. In general, the Inspector relieves the Chief of Station of much work, keeps the officers up to theirs, and insures uniformity in the various duties. Thus the Chief of Station is constantly able, through the Inspector, to ascertain the exact condition of all war material and to satisfy himself concerning the discipline of the men.

For artillery and torpedo material there are two inspectors sent directly from the Ministry of Marine and who report direct to its Chief.

Every year the Chiefs of Station hold fortification manœuvres, which are carried out chiefly by the Naval Artillery and Infantry, but the torpedo boats and ships in commission also engage in them. Ships that have hoisted a commander's pennant without belonging to a squadron and have have not left the Baltic or the North Sea are always under the orders of the Chief of the Station. Even the chiefs of squadrons and other naval authorities not under the command of the station are bound to take part in the Great Manœuvres. The latter take place at the end of summer, the Chief of Station deciding the period according to instructions from the Ministry. The plan is usually left to him, unless the Ministry wishes some particular operations to be carried out. The manœuvres generally cover measures which would be taken in event of a sudden declaration of war. Besides this, partial manœuvres are sometimes required; they are generally under the guidance of the different chiefs of division.

When, in 1877, the German Navy undertook the defense of the coast it was a step in the right direction, for such defense is naturally organized best by a sailor. The service in the coast forts is easy to the commanders of the Navy, for they are accustomed to complicated exercises on board a moving ship. Now that the forts on the coast and the torpedo defenses are commanded by naval officers and manned by sailors, Germany has reached a unity in the defense of the coast that can scarcely be found in any other country.

MOBILE DEFENSE.

The policy governing the organization of the mobile defense is apparent from one of the recent Estimates, which says:

> The larger the number of ships employed on political service the less they can be reckoned on for efficient coöperation with the floating means of defense that can be disposed of in the direct protection of the littoral, and also the more difficult and slow becomes the mobilization of the ships destined for local movable defense. For the more these vessels are kept waiting for the arrival of complements from the Reserve, the less chance they have of being supplied with crews already familiar with the ships in which they will have to serve. Hence what is gained on the one hand by increasing the more distant action of the fleet is lost on the other in the want of promptness with which the movable coast defense can be organized. It is incumbent, therefore, that one should seek to keep the defense in some other direction. Maritime strongholds are in the same condition as frontier fortresses and require garrisons sufficient for first defense, and must also have their material ready to enter promptly into action.

In fact, it may be said that no frontier force is required to be ready for war so promptly as that of the maritime strongholds, since not one of them is exposed to such sudden attack directly war has broken out. To be convinced of this it is only necessary to remember that a French squadron assembled at Toulon could appear before Spezia in less than 24 hours; that an Austrian squadron stationed at Pola could appear before Venice in less than 12 hours; or an English squadron at Halifax before Boston in less than 26 hours.

To attain this end a Naval Reserve Division has been formed for the military ports. It is composed of armored vessels, one of which, acting as a nucleus, has its full complement, while the others are in a comparative state of readiness for sea. When mobilization takes place, the crew belonging to the nucleus or central ship is distributed among the others, whose complements are then filled up from the garrison or from the first men of the Reserve who put in an appearance. By this means the ships which are indispensable to the defense are furnished promptly with complements, a portion of whom at any rate are already familiar with their vessels.

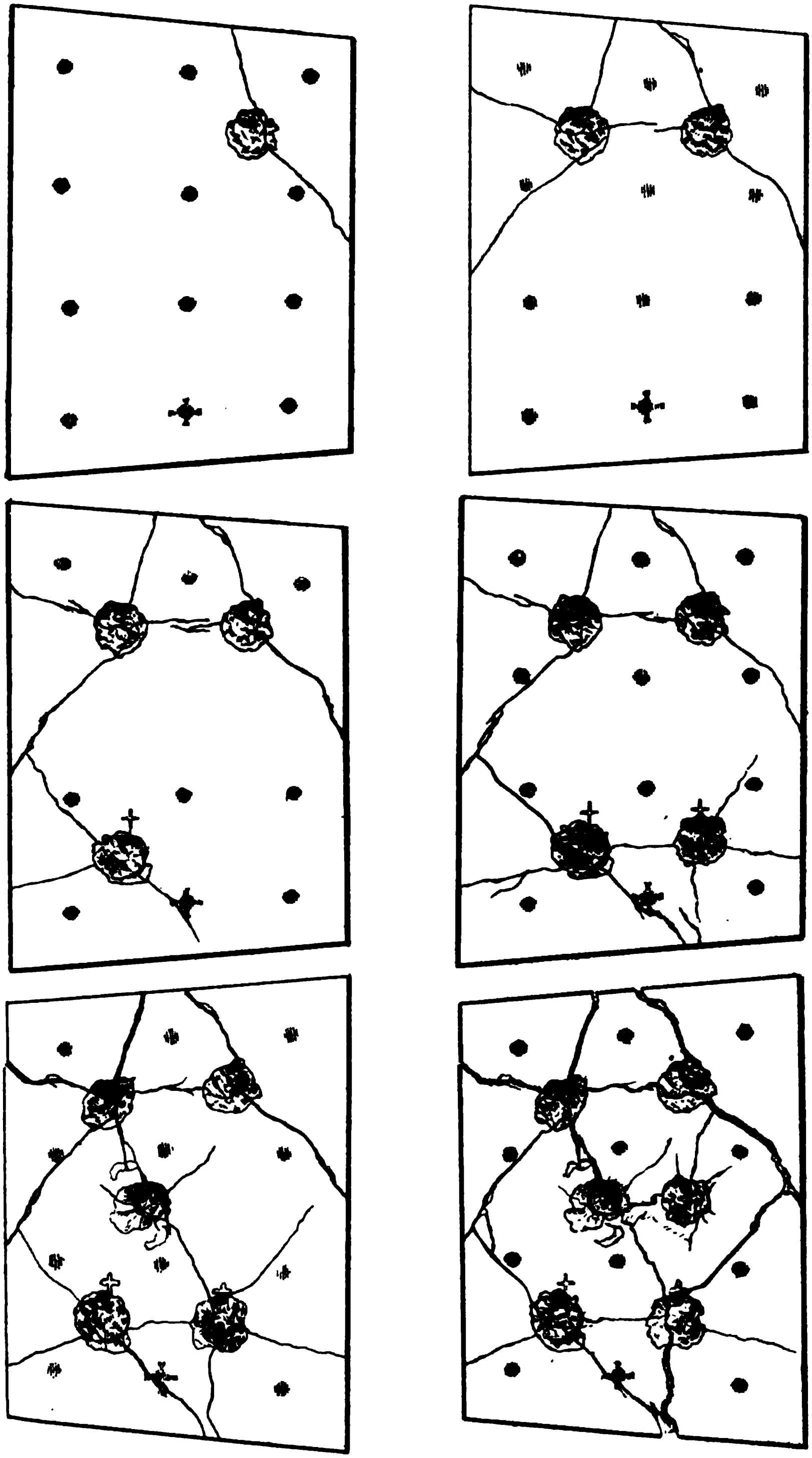
Among the vessels assigned to the local defense are torpedo boats, gunboats, ironclads, and small dispatch vessels and cruisers for scout service. All these vessels are kept ready for sea; and every year a portion of them are mobilized, during the autumn manœuvres, to make sure of their practical and efficient preparation.

For torpedo boats and mines there are four principal stations corresponding to the four coast districts, of which Wilhelmshaven, Kiel, Stralsund, and Dantzig are headquarters. These four stations are supplied by the general depot at Friedrichsort. Each is under a commander, assisted by five torpedo officers.

Secondary stations have been established, where material and supplies are stored; they are divided into two classes.

PLATE B.

SCHNEIDER PLATE TREATED BY HARVEY PROCESS



SUBMARINE DEFENSE.

Since assuming control of this branch of the defense the naval authorities have administered it with the same rigid care and exactness of preparation and drill that mark the other elements of the system.

The transfer of this branch and of the coast defenses in general from the Army to the Navy is everywhere conceded to be attended by the most satisfactory results. Naval and Army officers of high rank in Germany express but one opinion, which is that the efficiency of the coast defenses as well as that of the Navy has been increased thereby.

ADMIRALTY INSTRUCTIONS ON THE GARRISON EXERCISES OF WAR PORTS IN RESPECT OF COAST DEFENSE.

1. In order to familiarize the naval personnel with the service of coast fortifications during war and when besieged, and to make sure that everything shall be in a constant state of readiness for war; and further, to subject to practical experiment the systems of armament in detail, annual exercises are to be carried out in the war ports of Kiel and Wilhelmshafen by sections of Naval Artillerymen and by the Marine Infantry battalions.

These exercises are to include: (1) General exercises; (2) supplementary instruction at the Naval Artillery gunnery school; (3) a certain number of supplementary exercises consonant in character with the main object. These are to take place after the Ministry of Marine has decided upon their date and duration.

Every possible attention is to be paid to the other practical exercises which have to be learned by the personnel, and on no account are the new instructions referred to to interfere with the instruction of the recruits.

In carrying out these exercises it is to be distinctly understood that they are not to be viewed in the light of sham fights, but that their object is to familiarize the personnel who take part in them more thoroughly with the various features and problems which crop up in the defense of the military ports, and by frequent combined exercises to arouse and foster in the minds of the Naval Artillery and of the Marine Infantry the sentiment of coöperation which the two arms should evince in actual warfare.

Any written communications and plans required in carrying on these exercises, in so far as they may refer to the defensive capacity of the works, are to be treated as confidential.

The Commander-in-Chief of the Naval Station, after consultation with the Commanding Officer of Artillery and Engineers, will give out the problem to be solved in the principal exercise, and will nominate a commander, who will be intrusted with its execution.

2. The principal exercise will have as its fundamental idea the manning and equipping of the military port, or of one of its sections, in such manner that the whole of the sections, or part of them, can be

were tested at Annapolis: one of all steel; one of steel treated by the Harvey process; two of nickel-steel, one of which contained a higher percentage of both carbon and nickel than the other; and one of a high carbon nickel-steel treated by the Harvey process.

Under ordinary circumstances we would not consider the trials of such thin plates, but the one last named gave such phenomenal results as, in connection with those obtained in the preceding detailed trial, to lead to the belief that a successful surface-hardening process has actually been obtained.

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Twenty-one shots were fired at the low carbon nickel-steel plate. A number of the projectiles perforated, the remainder rebounding broken after considerable penetration. Plate not cracked.

Twenty shots were fired at the Harvey treated steel plate. None of the projectiles penetrated more than 2 inches, but the plate was much cracked, and was broken into four pieces.

Twenty-one shots were fired at the high carbon nickel-steel plate. The plate was neither perforated nor cracked. One projectile penetrated far enough to raise a bulge on the back of the plate, while the others all rebounded broken after slight penetration.

Twenty-one shots were fired at the Harvey treated nickel-steel plate, and the results obtained were wonderful. Only three of the projectiles penetrated more than half an inch, and all of the projectiles were smashed, disappearing in small fragments. A single crack, which did not extend to an edge of the plate, was developed at the twelfth shot. This crack was slightly extended by one of the succeeding shots.

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In conclusion, we feel safe in stating that the Harvey, or some equally effective, surface-hardening process is a step toward the realization of the manifest advantages of a compound system of armor, which previous processes have failed to supply; and, in assuming that if nickel-steel is successfully treated by some such process, it will undoubtedly surpass both compound and steel armor as a protection for war vessels.

sufficiently in case of sudden attack with the appliances of peace, the Commander-in-Chief should work out a plan of defense for the peace footing.

The personnel is to be distributed, exercised, and instructed according to this plan, and the works are to be manned on the signal "To arms." These exercises are to be followed by criticisms on the part of the officers who have taken part in them.

On the 1st of March annually the Commander-in-Chief will send to the Ministry a programme of the exercises to be carried out during the year, using the preceding details as a general guide.

On the 1st April annually a résumé is to be sent to the Ministry of the exercises of the past year, involving warlike operations connected with the fortress. This résumé should be accompanied by plans and any opinions relating thereto. These reports will be referred back to the Commander-in-Chief of the Stations, who will keep them in special files provided for the purpose.

Concurrently with the report a memorandum will be prepared of all questions and problems that suggest themselves.

COAST GUARD.

The Semaphore Service is in the hands of the Navy. It is recruited from men who have received a naval training. There are about sixty stations. The fixed material of these stations is already in position, and is under the custody of the nearest light-house keepers; the movable material is kept ready in chests to be forwarded to the locality on mobilization. A naval officer inspects the stations annually. In war the personnel of the light-houses, of the fog-signal stations, and of the other coast services assist in the lookout work.

The Navy has also carrier-pigeon stations for communication between the outlying islands and the mainland and from vessels on scout service.

The recruiting and calling out of the Reserves, both for sea and land service, is under the charge of the War Administration, which forwards to the Navy the personnel belonging to the naval levy.

The Naval Reserves comprise—

A First Reserve, or Seewehr, which includes only such men as have seen active service. It corresponds with the Landwehr of the Army.

A Second Reserve, corresponding to the auxiliary or Ersatz Reserve of the Army.

FRANCE.

In France the personnel of the coast defense was, under various names, in the hands of the naval administration from the time of Henry III to that of the first Republic. Under the latter this traditional institution was destroyed; but it was reorganized by Napoleon, who, by his decree of the 4th August, 1810, intrusted the command of the entire coast defense to a naval officer, the Ministry of Marine being charged also with the defense of Brest and Rochefort.

were tested at Annapolis: one of all steel; one of steel treated by the Harvey process; two of nickel-steel, one of which contained a higher percentage of both carbon and nickel than the other; and one of a high carbon nickel-steel treated by the Harvey process.

Under ordinary circumstances we would not consider the trials of such thin plates, but the one last named gave such phenomenal results as, in connection with those obtained in the preceding detailed trial, to lead to the belief that a successful surface-hardening process has actually been obtained.

These plates were the first ever manufactured by Carnegie, Phipps & Co., and were attacked by a Hotchkiss 6-pounder rapid-fire gun with steel a. p. projectiles having a striking velocity of 1,804 f. s. The striking energy employed, as compared with that necessary to just perforate a wrought-iron plate of the same thickness, was about 1.71.

Ten shots only were fired at the all-steel plate, at the end of which the plate was practically wrecked.

Twenty-one shots were fired at the low carbon nickel-steel plate. A number of the projectiles perforated, the remainder rebounding broken after considerable penetration. Plate not cracked.

Twenty shots were fired at the Harvey treated steel plate. None of the projectiles penetrated more than 2 inches, but the plate was much cracked, and was broken into four pieces.

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(5) Corps of torpedo artificers to manage and repair torpedoes, the machinery of torpedo boats, electric apparatus, etc

The manning of batteries and the service on shore may also be supplemented by naval gunners when the requirements of the fleet allow of their disposal.

A certain number of retired naval officers perform technical duties on shore.

The Army assists in the protection of the naval ports by manning all forts not on the sea front, and, in general, in defense against an attack from the land side. Should the attack be solely from the sea, the army may be sent, if necessary, by order of the maritime prefect to rëenforce the Marine Artillery in the sea forts; and as has frequently happened in war, when the Army forces were required elsewhere *all* of the forts are manned by sailors, by the Marine Infantry, and the Marine Artillery.

SUBMARINE DEFENSE.

On the 6th March, 1886, a ministerial decree created an additional department in the Ministry of Marine called the Direction of Submarine Defense. It has control of all torpedoes, mines, and apparatus used in connection with these, and of all torpedo boats. The Director of Submarine Defenses is a Rear-Admiral. Officers of this bureau inspect the submarine defense of the ports at certain periods as directed by the Minister of Marine.

At Cherbourg, Brest, and Toulon there is a Director of Submarine Defense under a Captain, who is directly dependent on the Maritime Prefect. The Director is stationed on board the central or headquarters ship of the movable defense, his time there counting as if he were in command at sea. He directs the whole of the local submarine defense, fixed and movable, is a member of the council of administration of the department, and is charged with the fitting on board ships of torpedo material, with the repair, maintenance, and regulation of such material, and with the maintenance of the first and second class torpedo boats. The Director is assisted by a local committee for studying questions connected with torpedoes, by a committee for experiments, and by a committee for regulating fish torpedoes.

In the minor naval ports, Lorient and Rochefort, the personnel for the submarine defense is under the orders of the Senior Naval Officer, a Rear-Admiral.

The submarine defense includes the fixed and the movable defense, together with the offices and rooms required for the purpose.

FIXED DEFENSE.

The fixed defense consists of obstacles or booms, submarine mines, search-light stations, steam launches fitted with spar torpedoes, and torpedoes operated from shore, care of material, mine boats, etc.

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COAST GUARD.

To provide for the semaphore service of the coast during peace and war, a line of 145 semaphore stations has been established, which are connected with the general telegraph system and manned by men of the Navy. These men are regarded as in civil employ, but they are sworn in and, during war, form part of the Reserve.

The stations on the coast of each maritime department are under the orders of the Maritime Prefect or Commander-in-Chief of the Department, who for this purpose is assisted by a naval officer of high rank, styled Inspector of Semaphore Service. Administratively, this service is under the direction of the General Staff.

In case of war the flotilla employed in the protection of the fisheries along the coast can be employed in the coast-guard service. Both the material and the personnel of this service are furnished by the Ministry of Marine.

As previously stated, the Semaphore Service is under a Rear-Admiral, with the title of Major-General of Marine and subordinate to the Maritime Prefect. He commands the personnel and is responsible for the maintenance of the stations. An official, appointed by the Director-General of Posts and Telegraphs, is stationed in each district and is responsible for the maintenance of the electric apparatus, wires, and submarine cables, and informs the signalmen of all orders relating exclusively to the electric-telegraph system.

The inspectors of semaphore service are appointed by the Minister of Marine. They are chosen from the active list of captains of the Navy and serve for two years. They can be reappointed for a similar period, but no longer. In Corsica, however, the inspector is usually a Lieutenant, who is at the same time aide to the Naval Commandant at that station. Inspectors report to the Major-General of Marine and are subject to his orders.

The personnel of each station consists of chief signalmen of the first and second classes and signalmen of first and second classes.

The inspectors have, under the authority of the Rear-Admiral, Major-General of Marine, the control of personnel and material of stations within the limits of their jurisdiction; they are also responsible to the latter officer for the maintenance of stations and material. They require the signalmen to coöperate with the agents of the Department of Posts and Telegraphs, who are charged with the maintenance of the electric material.

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DECREE OF 13TH MAY, 1890.

Under the law of France, the Minister of War is still charged with the defense of the land frontiers and of the coast proper. In case of war, the Ministries of War and of Marine must, of course, coöperate in the defense of the latter. Recognizing the great importance of agreement and unity of action between the two departments, their Ministers have agreed to place the personnel and material of both services under the same command; and as it is regarded that such command falls most naturally within the province of naval authority, it has been given to Maritime Prefects. In all matters affecting the land forces of their districts, the Maritime Prefects are under the orders of the Minister of War. The Commandants of Sections, who are also naval officers, are invested by the Ministry of War with authority over elements under its jurisdiction and by the Ministry of Marine over matters within its province. By this combination the Minister of War, while still keeping his responsibility, is left free to devote his attention to the armies in the field and their theatres of war. This system has the force of law, having been promulgated by the President of France in a decree of the 13th May, 1890.

The two Ministries inform each other of all orders or instructions given to the Maritime Prefects and Commandants of Sections.

In the section of Antibes the coast railway, being one of the most important communications of the Army in the Alps, is placed under the General commanding that force.

Generally speaking, the governors of all towns and works on the coast are under the authority of the section commandants. Exceptions occur in the governors of Belle-Isle and of Ré and Oleron Islands, who receive orders direct from the Maritime Prefect of their district. The commandant of the Marseilles section is under the orders of the General commanding the Army Corps in that region in matters relating to the sea front of Marseilles itself, but is responsible to the Maritime Prefect alone for the rest of the section.

The governors of Dunkirk, Bayonne, Port Vendres, and Nice, are also commandants of the sections in which those places are situated.

Table showing Sections of the coast of France.

Maritime district.	Section.	Seat.	Extent of Section.
First	Dunkirk	Dunkirk	From frontier of Belgium to mouth of the Authie.
	Havre	Havre	From mouth of Authie to Tancarville, including mouth of the Seine.
	Caen-Cherbourg.	Caen	From mouth of Seine to western limit of first district.
Second	Saint Malo	Saint Malo	From western limit of first district to Cape Fréhel.
	Saint Brieuc	Saint Brieuc	From Cape Fréhel to mouth of the Douron.
	Brest	Brest	From mouth of Douron to southern limit of zone under Maritime Prefect.
	Quimper	Quimper	From the latter zone to southern limit of second district.
Third	Lorient	Lorient	From north limit of third district to Pointe du Grand-Mont.
	Saint Nazaire	Saint Nazaire	From Grand-Mont to south limit of third district.
Fourth	Ile Yeu-la-Rochelle.	Sables d'Olonne	From north limit of fourth district to the zone under Maritime Prefect.
	Bordeaux	Royan	From latter zone to Arcachon basin.
	Bayonne	Bayone	From Arcachon to frontier of Spain.
Fifth	Perpignan	Port Vendres	From Spanish frontier to mouth of the Agly.
	Cette	Cette	From the Agly to mouth of Rhone.
	Marseilles	Marseilles	From the Rhone to zone under Maritime Prefect.
	Antibes	Cairnes	From latter zone to mouth of Var.
	Nice	Nice	Mouth of Var to frontier of Italy.

This decree is regarded too as preliminary to a final transfer of the entire coast-defense to the Navy. The necessity of undivided authority; the advantage of having coast garrisons who can coöperate actively with the submarine-mine detachments and, if necessary, render them practical assistance; the further advantage of manning all works on the coast with men familiar with their most probable enemy, knowing his vulnerable points, and understanding his manœuvres; the advantage, claimed by the Germans for their system, of having men in all the coast fortifications, who join from the Naval Reserves and are familiar with the guns used in such works and of the same type as those on shipboard; all these are recognized in France as the basis of the present compromise as well as of the early control of the Ministry of Marine over every element in the defense of the littoral.

ITALY.

The present system of coast defense in Italy is the result of much study, long experience, and many experiments. Its great extent of coast, the comparatively unprotected state of its most important ports, and the variable depths of its coast waters make it dependent upon such protection as can be secured only by a naval force. The principal element in the Italian system is therefore naval.

In addition to providing the first line of defense, the Navy controls the second line of coast and torpedo batteries and search-light stations, as well as the third line of obstructions and submarine mines. These duties, together with those attaching to the harbor-defense vessels and torpedo boats and launches, give to the Italian Navy a prominence in the coast defense that is commensurate with the value of its work.

The general functions of the Navy in the defensive system may be classed under the following heads:

1. An opposing fleet.
2. Cruising torpedo boats.
3. Coast torpedo boats.
4. Obstructions.
5. Stationary torpedoes.
6. Dirigible torpedoes.
7. Submarine mines.
8. Coast batteries.
9. Search-light stations.
10. Semaphore service.
11. Consulting officers in forts.
12. Fortifications at Taranto and at the Maddalena.

The supreme authority in all matters relating to coast defences is vested in the Commanders-in-Chief of the three Maritime Departments, the headquarters of which are Spezia, Naples, and Venice. In addition to these three cities, Maddalena, Taranto, Genoa and Gaeta are local-defense commands. By recent orders, Maddalena and Taranto have been made Rear-Admirals' commands, though subordinate to the Commander-in-Chief of the Department, while Genoa and Gaeta are commanded by Captains.

LOCAL NAVAL DEFENSE.

The command of this service is directly subordinate to the authority of the Commander-in-Chief.

A superior officer of the General Staff of the Navy is commandant of local-defense and controls its personnel and equipment as well as the complement of the central ship which is under his command. He is charged with all the duties of the commander of a ship and those of a local commandant. The same rules of discipline and administrative power apply to him as to them, either in his relations to the Commander-in-Chief, the departmental authorities, his subordinates, or to the Army or civil authorities of the district.

He is responsible for the material and stores as well as for the instruction of the personnel, so that the local defense may be in an efficient state. He submits to the Commander-in-Chief a list of the personnel and its distribution, including the force for duty in the event of action; also a programme of exercises. Once a month he reports to the Commander-in-Chief the condition of the local defense and the state of efficiency of the personnel.

The commanders of the fixed and of the mobile defenses are subordinate to the commandant of the local defense and are responsible to him for the maintenance and the preservation of material in their charge and for the instruction of their men.

The commandant has also under his charge the men and equipment of the semaphore stations and of the defensive works and torpedo stations within the jurisdiction of his coast line. He must maintain a constant lookout, and in event of a disaster at sea must render any assistance in his power.

The central ship must maintain, as far as possible, steady communication with the semaphore stations, the men-of-war, and the torpedo vessels in sight, and, in time of war, with the nearest telegraphic station, a subordinate being detached for that purpose.

A lieutenant acts as secretary to the commandant, keeping a record of all exercises and experiments and of all technical matters relating to the command.

The paymaster of the central ship renders an account, in addition, of all the stores belonging to the fixed or mobile defense.

The chief engineer of the central ship is also charged with the duty of seeing that the engines of the torpedo boats and other vessels belonging to the local defense are kept in a proper state of preservation and repair.

The Commander-in-Chief, or other officer of superior rank directed by him, must satisfy himself by inspection from time to time of the condition of the local naval defense along the coast under his jurisdiction.

The vessels belonging to the local defense are considered, for administrative purposes, as being in reserve; that is, with sufficient stores and crew for harbor service, with machinery in good order, and ready for full commissioning at any moment.

A detail is made annually of general-service men, who shall be supplied to the commandant of local defense in case of mobilization on a war footing. The gunners and torpedo men of the coast defense furnish the nucleus of this force, a certain number of men who have served their time being devoted to this service and having a special uniform.

FIXED DEFENSE.

The commander of the fixed defense has under his authority the personnel assigned to that service and is responsible to the commandant of the local defense for the maintenance of his stores and material and the efficiency of his men. He is also the second in command of the central ship of the local defense and is a member of the General Staff.

The fixed defenses comprise—

(*a*) Torpedo lines and submarine mines, their connections and other accessories, and all other obstructions.

(*b*) Torpedo batteries, floating batteries, and lighters; search-light stations.

(*c*) Coast batteries for the protection of submarine mines and torpedoes.

(*d*) Launches and lighters for laying out mines or torpedoes.

(*e*) Semaphore stations.

(*f*) Telegraph and telephone lines belonging to the Navy.

(*g*) Electrical firing stations.

(*h*) All material, magazines, and storehouses of the fixed defense.

A detachment of the local naval defense serves on shore in charge of the firing stations for submarine mines, in the dirigible torpedo batteries and search-light stations, in the coast batteries covering mines and torpedoes, in the semaphore, telegraph, and telephone stations, and in the magazines and storehouses.

If for exceptional works or for war purposes an increase of the force should be necessary, it must be provided through the direction of the Commander-in-Chief of the Department from the Corps of Royal Reserves.

MOBILE DEFENSE.

The chief of the mobile defense commands the personnel assigned to that service; his responsibility to the commandant of the local defense corresponds to that of the commander of the fixed defense. He belongs also to the General Staff and commands one of the vessels assigned to this defense.

The mobile defense comprises:

(*a*) The central ship of the local defense, on which is quartered the personnel of such defense, excepting the crews of torpedo boats or other harbor-defense vessels.

(*b*) Torpedo boats, launches, and harbor-defense vessels, with their armaments, ammunition, and other stores belonging to them.

The personnel consists of the crews of torpedo boats, of the tugs, pontoons, launches, and other small craft assigned to this defense, and of the men in charge of depots and stores.

The torpedo boats are exercised frequently, either singly or in company, and every opportunity is taken to afford the crews an exact knowledge of the coast.

The complements of torpedo boats are calculated according to the number in commission; but, in addition, one complete crew is allowed for each group of three torpedo boats not in commission. These complements are not changed in any particular, except under special circumstances and for service reasons.

In forming torpedo-boat crews preference is given to men born or resident in the vicinity; a note is made of those men who have deserved special mention when forming part of the crew of a torpedo boat.

The charge of the depots for materials and stores of the mobile defense is given preferably to members of the detachment for local defense or to seamen of the gunner and torpedo classes.

PERSONNEL OF THE LOCAL DEFENSE.

The personnel for local defense is recruited from seamen who have served their time in the Navy or who are on unlimited leave, which is almost equivalent to a discharge. The gunners and torpedo men are recruited from those who have passed through the courses in the respective schools, certain inducements of promotion being held out to them if they enter this service.

The general muster lists of the local defense comprise:

(1) The list for usual service, showing the distribution of personnel and the duties of those in charge of stores in time of peace.

(2) The list for preparatory action, showing the personnel necessary for promptly placing the defense upon a war footing, for the laying of submarine mines, lines of torpedoes, sunken barriers, etc.

(3) The list of the full war strength when the defenses are placed on a war footing.

These lists are combined so as to obtain the advantages of the promptest action in emergency together with the greatest economy in the number of men borne for service. The complements for peace footing are decided by the Ministry of Marine on the recommendation of the Commander-in-Chief, as also the number and ratings of the men to be furnished from the reserves to complete the lists for preparatory action and for full war strength.

The orders for carrying out exercises and manœuvres approximating actual warfare emanate from the Commander-in-Chief, who thus assures himself of the efficiency of the stores and material of the local defense and of the fitness and capacity of the personnel.

The routine of periodical drills or exercises is drawn up by the commandant of the local defense and submitted for the approval of the Ministry of Marine through the Commander-in-Chief.

The entire service is so regulated that at any period of the year the local defense may be placed either on a partial or complete war footing.

Complement assigned in time of peace to the local defense of Spezia.

Grade.	Defense.		Crew of central ship	Total.
	Fixed.	Mobile.		
Captain, in command of local defense and of central ship	1	....	....	1
Commander, in command of fixed defense	1	....	....	1
Lieutenant commander	....	1	....	1
Lieutenants	3	2	1	6
Sublieutenants	....	....	2	2
Chief engineers	....	1	1	2
Paymaster	1	....	....	1
Surgeon	....	....	1	1
Boatswain	....	....	1	1
Second boatswains	2	....	1	3
Boatswain's mates	1	....	2	3
Seamen, first class	....	....	12	12
Seamen, second class	43	4	12	59
Seamen, third class	....	....	12	12
Chief quartermaster	....	....	1	1
Second chief quartermasters	2	....	....	2
Quartermasters	6	....	....	6
Gunner, first class	....	....	1	1
Gunner, second class	1	....	....	1
Second gunners	1	....	1	2
Gunner's mates	5	....	1	6
Seaman gunners, first class	10	....	6	16
Seaman gunners, second class	8	....	6	14
Torpedo artificer, first class	....	....	1	1
Torpedo artificers, second class	2	1	....	3
Second torpedo artificers	3	1	....	4
Torpedo mates	13	2	....	15
Torpedo men, first and second classes	50	7	....	57
Engineers, first class	1	....	1	2
Engineer, second class	....	....	1	1
Engineers, third class	2	1	2	5
Chief fireman	....	....	1	1
Firemen, first-class	5	1	4	10
Firemen, second-class	5	1	8	14
Aide, second-class	....	....	1	1
Carpenter	....	....	1	1
Sail-maker	....	....	1	1
Armorers	1	....	1	2
Torpedo mechanics	1	2	....	3
Second apothecary	....	....	1	1
Nurse	....	....	1	1
Yeomen	4	....	1	5
Yeomen's mates	4	....	....	4
Paymaster's yeoman	....	....	1	1
Cook	....	....	1	1
Total	176	24	68	268

The surgeon is embarked only when ordered by the Ministry of Marine. Six of the yeoman in the foregoing complement must have passed the course at the telegraph school.

Spezia is perhaps the most thoroughly fortified stronghold on the

Mediterranean. The complements assigned to the headquarters of the other maritime departments are smaller, and depend, of course, upon the extent of the defenses, varying with their increase or decrease. In 1887 the complement for Venice was 139 officers and men; for Naples, 93, and for Maddalena, 91.

TORPEDO STATIONS.

A most important feature of the Italian system is the apportionment of the torpedo boats to stations which embrace the entire coast of the peninsula. The number of stations and their coast limits have been changed several times. The following are at present the principal and secondary torpedo stations for purposes of coast defense:

Department.	Principal station.	Extent of coast.	Secondary stations.
No. 1	Spezia	From the French frontier to Terracina, inclusive.	Porto Maurizio. Oneglia. Genoa. Porto Ferraio. Porto S. Stefano. Civita Vecchia.
	Maddalena	Sardina and its islands	Cagliari. Porto Conte.
No. 2	Gaeta	From Terracina to Cape Survero	Salerno.
	Messina	Sicily, its islands, and the main coast from Cape Survero to Cape Spartivento.	Milazzo. Palermo. Trapani. Marsala. Siracusa. Augusta.
	Taranto	From Cape Spartivento to Cape St. Maria di Leuca.	Catrone. Gallipoli.
No. 3	Ancona	From Cape St. Maria di Leuca to the mouth of the Rubicon.	Brindisi. Bari. Manfredonia. Tremiti.
	Venice	From mouth of Rubicon to Austrian frontier.	Porto Corsini.

The principal stations are so organized and equipped as—

(*a*) To afford safe shelter for at least nine torpedo boats.

(*b*) To be within easy distance of workshops for minor repairs.

(*c*) To possess means for lifting out of water at least one boat, or to be in proximity to a suitable locality for the same.

(*d*) To have a sufficient supply of fresh water for the torpedo boats belonging to the station and for their crews.

Each principal station moreover contains—

(*a*) A magazine for twelve torpedoes and charges.

(*b*) A magazine for the machine guns, arms for the crews of nine torpedo boats, and ammunition.

(*c*) A storehouse for coal, and lubricating material for supplying nine torpedo boats three times.

(*d*) A storehouse for 2,000 rations.

(*e*) A dormitory for 36 men.

(*f*) A dormitory for six petty officers.

(*g*) A kitchen for 48 men and 12 officers, with necessary outfit.

Each principal station is also provided with—

(*a*) A pneumatic steam pump for charging torpedoes.

(*b*) A signal mast, with complete outfit of flags and other signal apparatus, including storm signals.

(*c*) A set of Very's signals in addition to those provided for the torpedo boats.

(*d*) A small siren for acoustic signals.

(*e*) A 7-centimetre gun for signaling, with removable carriage.

The secondary stations are so organized and equipped as—

(*a*) To afford safe shelter for at least three torpedo boats.

(*b*) To have a sufficient supply of fresh water for at least three torpedo boats and their crews.

(*c*) To have a sufficient supply of coal and lubricants for supplying three torpedo boats three times.

(*d*) To be provided with quarters for the warrant or petty officer in charge of stores and his assistant.

(*e*) To be provided with a signal mast and complete signal outfit for day and night.

The command of each principal station is assigned to a Lieutenant-Commander or to a Lieutenant, according to its importance. He is responsible to the Vice-Admiral in command of the Maritime Department in which the station is situated.

Each station is inspected every 6 months by the Vice-Admiral or his representative.

The military jurisdiction of each principal station extends over the extent of coast allotted to it, including also the respective secondary stations.

The commander of a station holds all the authority and position of the commander of a ship, and that of a local maritime command.

He is responsible for the proper care and maintenance of all stores and equipments at the principal and secondary stations, and must keep the torpedo boats ready for sea at any moment.

He is charged with the instruction and discipline of his men, and must maintain a constant watch along the coast and render every assistance with the means at his command in case of accident at sea.

He must see that the principal and secondary stations maintain communication by signal flags with the semaphores, with war vessels and torpedo boats in sight, and that storm signals are displayed when necessary.

During war, when a semaphore station is not visible, he must establish communication with the nearest one, and also with the nearest telegraph station, detaching some of his men for that duty.

He must also keep watch over the semaphore stations and coast defense works belonging to the navy along his extent of coast, and once a month must proceed in a torpedo boat to inspect them, as well as the secondary stations, reporting the result to the Commander in Chief.

The torpedo boats must be exercised as often as possible, and every opportunity taken to familiarize the men with the coast.

The complement of the principal stations corresponds with the number of torpedo boats assigned to them, with the addition of a petty officer and men in charge of stores, and the personnel of the fixed defense. For the secondary stations there are only the petty officer in charge of stores and his assistant.

In assigning the complement of stations preference is given to men who are natives of the locality or whose families reside on the spot. No change is made in the higher grades of station personnel except for reasons of health, discipline, or a particular emergency, and in the latter case the approval of the Commander in Chief must be first obtained.

The crews of torpedo boats at the principal stations sleep on shore, excepting those left in charge of each boat at night.

An armed guard is stationed over all magazines containing explosives; and during war a patrol of the coast and of the semaphore stations is required. In the latter duties the engineer's force of the torpedo boats and the officers' attendants must take their turn. During peace this duty is carried out by the guard over the magazines; and, in the absence of the torpedo boats, by the men in charge of stores, who must be competent to read signals from war ships at a distance or from semaphore stations.

Should it become necessary to inflict punishment and no suitable place of confinement is available, the offender is transferred to the department headquarters without delay.

All sanitary measures are regulated by the commandant in the same manner as on board naval vessels.

The invoice of articles allowed the men's quarters at a principal station is as follows:

No.	Articles.	Total value.	No.	Articles.	Total value.
		Francs.			*Francs.*
30	Bedsteads		1	Grater	5.0
3	Mess tables	48.0	1	Cask, 50 litres	5.0
6	Wooden benches, 1.8 by 1.3 metres	30.0	1	Washing tub	2.50
			2	Tubs	4.0
6	Wooden benches, 1.3 metres	24.0	2	Barrels for wine	10.0
1	Copper boiler	35.0	2	Barrels for water	10.0
1	Saucepan	35.0	1	One-half pint measure	1.50
1	Copper boiler	5.25	1	Pint measure	1.75
1	Stool	3.0	1	Forty-three one-hundredth pint measure	1.25
1	Mill	5.0			
3	Ladles	11.25	6	Canvas aprons	12.0
2	Lanterns	8.0	2	Canvas sacks	10.0

No.	Articles.	Total value.	No.	Articles.	Total value.
		Francs.			*Francs.*
1	Hatchet	4.0	8	Black-handled knives	8.0
4	Hampers	18.0	1	Ladle	5.0
2	Pickaxes	12.0	1	Salad spoon and fork	2.0
1	Coffee sieve	4.0	3	Tablecloths	18.0
2	Cleaners	5.0	24	Napkins	16.80
1	Cheese cutter	3.0	8	Cups and saucers	22.0
1	Pair scales	12.0	8	Napkin rings	8.0
2	Funnels	4.25	6	Dusters	6.0
	Sundry utensils	21.0	6	Canvas aprons	12.0
8	Chairs	12.0	1	Copper boiler	10.80
2	Mirrors	18.0	2	Saucepans	26.05
2	Iron stands for basins	4.0	1	Pie dish	8.70
6	Beds, complete	517.80	1	Fryingpan	3.50
2	Iron basins	6.0	2	Cooking spoons	3.50
2	Milk pans	5.05	2	Iron skimmers	1.50
2	Lockers	150.0	2	Cleavers	5.0
1	Soup tureen	5.0	1	Grater	3.0
1	Salad bowl	3.0	2	Small casks	10.0
1	Earthenware dish	2.25	2	Funnels	1.70
12	Soup plates	3.60	1	Dishpan	2.50
24	Plates, large	6.72	1	Gridiron	3.50
18	Plates, small	4.0	6	Baking dish	6.0
8	Tumblers	4.0	1	Toasting fork	1.50
8	Decanters	6.0			
2	Salt cellars	2.0		Total	1,335.17
8	Plated spoons and forks	50.0			

Invoice of articles for a secondary station.

8	Beds	....	1	Tin box	2.0
1	Table	15.0	1	Hamper	6.0
1	Coffee boiler	7.0	2	Pickaxes	2.80
1	Kettle	15.0	1	Percolator	2.40
1	Kettle	7.50	2	Cleavers	2.80
1	Stool	2.40	1	Cheese cutter	1.20
1	Mill	8.0	2	Funnels	1.70
3	Ladles	1.50	1	Canvas bag	1.70
1	Lantern, large	10.0	2	Wooden lockers	228.0
1	Lantern, small	4.0		Sundry utensils	5.0
3	Barrels	18.0	1	Pair of scales	12.0
1	Quart measure	.80	1	Grater	1.25
1	Pint measure	.60	1	Coffee sieve	.90
1	Half-pint measure	.40			
1	Axe	2.50		Total	360.45

FORTIFICATIONS.

In general terms, all forts occupying elevated positions are garrisoned by the Army, while the coast batteries, including those covering submarine mines and other obstructions, are manned by the Navy. A marked exception to this rule occurs at Maddalena and Taranto, where *all* the fortifications are in the hands of the Navy.

At Taranto the defenses are merely begun, but at the Maddalena they are very complete; and whether batteries covering torpedo lines, earthworks on headlands, masked redoubts, stations for controlling indirect fire, pits for disappearing guns, or the extensive forts on the peaks—all are built, manned, armed, and controlled by the naval forces, and are subject only to the authority of the Rear-Admiral commanding the Dockyard and Station.

For the design and construction of fortifications belonging to the Navy a general officer of Army Engineers is detailed as Chief of the Office of Military Engineering in the Ministry of the Marine, and is regarded as temporarily detached from the Army. He is intrusted with the design of all the forts, dry docks, improvements in dockyards, buildings, etc., and in the execution of such designs is aided by other engineer officers, who are placed temporarily under the orders of the Ministry of Marine. At the Maddalena the works were of such importance that a board of six officers and four employés were so detailed from the Corps of Engineers.

GENERAL STAFF.

The General Staff, whose Chief is the President of the Superior Council of the Ministry of Marine, forms a separate bureau without administrative functions.

It is charged with the study of all that relates to the organization of the naval forces, the plans of campaign, the defense of the coast, and questions of naval tactics and strategy.

CONSULTING OFFICERS IN FORTS.

An additional province has been assigned to naval officers, as the result of the annual manœuvres in which the fleet simulated an attacking force against the works and personnel of the local defense. Notably at Spezia, where the upper forts are garrisoned by troops of the Army, it was found that army officers could rarely distinguish between the vessels of the attack and the defense; and, in some instances, could detect no difference between a merchant vessel and a cruiser or armored ship. It became necessary, therefore, to station naval officers in the forts as experts to point out the several classes of vessels and to distinguish between friend and foe. They are also most useful in signaling to the defensive fleet in emergency and when combined operations are rendered necessary through an unforeseen contingency.

PROVISION AND COAL DEPOTS.

As food and coal supplies are most important elements in an effective defense of the coast, depots have been established in the more important ports.

Provisions for an emergency are stored as follows:

	Rations.		Rations.
Spezia	200,000	Taranto	30,000
Naples	125,000	Venice	30,000
Messina	60,000	Maddalena	25,000

Coal, in varying quantities depending upon the importance, strategic value, and defenses, is kept at the following ports:

Spezia.
Porto Torres.
Civita Vecchia.
Palermo.
Taranto.
Ancona.
Cagliari.
Maddalena.
Naples.
Gaeta.
Messina.
Alberoni.
Livorno.
Porto Ferraio.
Castellamare.
Augusta.
Brindisi.
Venice.

SEMAPHORE SERVICE.

The semaphore system, which is intimately connected with torpedo-boat defense, was transferred from the Ministry of Public Works to that of the Marine, in July 1887. Its personnel is now organized upon a naval basis.

The connections overland or by cable, between the semaphore stations and the telegraph lines of the kingdom, were not included in this transfer; they are still repaired and maintained by the general telegraph service, which is owned and controlled by Government.

There are 45 semaphore stations, as shown by the following list; those marked M are meteorological stations also.

No.	Name.	Height above sea.	No.	Name.	Height above sea.
		Metres.			*Metres.*
1	Alberoni, Venice	24.27	24	Monte Saraceno, Gorgona	180.60
2	Asinara, Sardinia	150	25	Palascia, M	85
3	Bari	39	26	Palmaria Island, M	201.60
4	Brindisi	27.30	27	Piombino, M	52.25
5	Campo delle Serre, Elba, M	600	28	Po di Primaro, M	21
6	Cape Carbonara	42	29	Ponza Island	279.75
7	Capo d'Armi	117	30	Portofino, M	578.60
8	Cape Ferro	46	31	Procida, M	115
9	Cape Mele	220	32	S. Benigno, Genoa	93
10	Cape Spartivento, Calabria, M	46.80	33	Santa Maria de Leuca	70.85
11	Cape Spartivento, Sardinia, M	207.69	34	Taormina	236
12	Cape Testa	56	35	Torre Chiaruccia	18.28
13	Cappucini d'Ancona	99.60	36	Torre Mileto, M	17.16
14	Island of Capri	273.40	37	Tremite	79
15	Cozzo Spadaro, Cape Passaro, M	51.40	38	Ventotene	106
16	Favignana Island, M	344.60	39	Cape Viesti	50.30
17	Forio d'Ischia	227	40	S. Teodoro, Sicily	27
18	Forte Spuria, Messina	97.80	41	Gorgona	255
19	Guardia Vecchia, Maddalena, M	152	42	Capraia	410
20	Massa Lubrense	242	43	Monte Grosso, Elba	347
21	Monte Argentaro	106	44	Capo d'Anzio	20
22	Monte Conero, M	548	45	Cape Caccia, Sardinia	185
23	Monte Pellegrino, Palermo, M	606			

The following semaphore stations were building on January 1, 1890:

No.	Name.	No.	Name.
46	Punta Falcone, Straits of Bonifacio	56	Cape Gallo.
47	S. Antiocco	57	Pantellaria.
48	Cape S. Elia, Sardinia	58	Licata.
49	Cape Bella Vista, Sardinia	59	Belvidere di Siracusa.
50	Cape Figari, Sardinia	60	Cape Colonna.
51	Monte Circello	61	S. Vito di Taranto.
52	Torre Orlando, Gaeta	62	Porto Corsini.
53	Cape Palinuro	63	Ustica.
54	Stromboli	64	Cape Noli.
55	Salina		

STAY OF ARMED VESSELS IN PORT.

A recent Royal Decree prohibits during peace the presence of more than three armed vessels of any foreign power, at one time, in any of the military ports; it also limits the stay of such vessels to a period of 8 days. The former provision is enforced rigidly; but the latter is waived upon application, if the reasons for such request are satisfactory.

Another regulation prohibits the passage of the Straits of Bonifacio by war vessels under easy steam and in proximity to the forts.

A Royal Decree of November, 1887, regulates the anchorage and stay of foreign vessels during war in the military ports of Italy. The latter are:

Spezia.
Savona.
Porto Ferraio.
Naples.
Genoa.
Porto Longone.
Venice.
Leghorn.
San Stefano(Argentaro).
Civita Vecchia.
Messina.
Taranto.
Gaeta.
Augusta.
Maddalena.
Siracusa.
Ancona.
Palermo.
Brindisi.

It is evident from this list that nearly every place of commercial importance on the seaboard is regarded as a military port also. This decree requires foreign war or merchant vessels to display their national colors on approaching any of the coast defenses; and they are not allowed to enter the zone commanded by the batteries without permission of the commandant of local defense. On noncompliance with this rule, the vessel shall be warned by firing a blank cartridge; should this prove insufficient, it shall be followed by a shot across her bows, and, finally, by a direct shot, if necessary.

A ship on being warned should stop and hoist its number, thus notifying the semaphore station of its wish to enter the harbor. It is required to remain hove to until the arrival of an official sent by the Commandant to authorize its anchorage and pilot it to its berth.

Should permission to enter be refused the semaphore station signals "No;" and if the vessel refuses or fails to draw off she is warned as already described.

The Commandant may allow vessels to moor or anchor within range of the fortifications, but under no circumstances are vessels of any description allowed to pass within the lines of submarine obstructions.

During war all private vessels and boats of neutral war ships are forbidden to move about the harbors or roadsteads; communication with the shore can be made only during the day and in accordance with rules issued by the local commandant. All vessels are forbidden to anchor at night in defended ports or to approach even within range of them. They are required to draw off at once on the discharge of the warning gun. Such rules do not apply, of course, to vessels used by the local authorities, nor to Italian war ships or to those of an ally.

PILOTAGE DURING PEACE AND WAR IN MILITARY PORTS.

During exercises in laying out mines or other submarine obstructions in time of peace the commandant of local defense is required to establish a temporary service of military pilotage. The personnel belongs to the local defense. This pilotage is independent of that exercised by the usual local pilots. Notice is given by the Commander-in-Chief of the Department of the beginning and end of such pilotage. The services of the military pilot are gratuitous, and his duty is simply to indicate the course necessary for avoiding the obstructions already laid out.

These pilots are furnished with certificates showing that they are employed only on the service of harbor defense.

During war the local pilot service is suspended, and all pilotage is controlled by the commandant of local defense. The corps of military pilots may be recruited from those engaged in the local service, provided they belong to the Naval Reserve or are enrolled in the military or naval service. Two lists of pilots are prepared annually, one of those actually in service and belonging to the local defense; the other of those belonging to the local pilot service. Those of the latter being liable to military service are classed as volunteers for pilot duty in time of war, and have the grade at least of a third-class boatswain. They wear the uniform of this grade, and have the title of sworn pilots.

Pilotage during war is gratuitous for national or friendly vessels, or even for those of an enemy's flag if provided with a safe conduct.

Sworn pilots are bound by an oath of loyalty; they are required to observe the utmost secrecy concerning the defenses, and are especially forbidden to indicate to the captain or crew of the piloted vessel the position of submarine mines or other obstructions.

AUSTRIA.

The defense of Austria by land and sea is under the direction of the Royal War Ministry, whose functions include the administration of the Navy. This system is attended by inconveniences, but it insures unity of conception and coöperation in the execution of campaigns, which is a factor of the highest importance.

In general terms the coast fortifications are under the orders of the Commander of the Army Corps stationed in the coast zone. The most notable exception is the fortress at Pola, which is the only naval arsenal of the Empire. Its command is intrusted to the Vice-Admiral Commander-in-Chief of the Station at Pola, who, as such, however, is under the orders of the Commander of the Army Corps. The Navy furnishes part of the garrison of the batteries and forts of Pola, and is charged entirely with its mobile and submarine defenses.

At those points of the coast possessing military importance, but at which maritime interests prevail, a naval officer is assigned as commandant of the fortress; and a naval officer is attached, for purposes of consultation and advice on naval matters, to the staff at all coast fortifications garrisoned solely by troops of the Army.

At sea the first line of defense is maintained by the fleet acting on the offensive, or the purely defensive, as circumstances may require. The second line belongs to the coast defense vessels, which manœuvre only on the defensive.

The Navy is also charged with the transportation, embarkation, and landing of troops, with the control of all mobile and submarine defenses, and with the organization and maintenance of all means of communication between the sea and the land.

Intelligent coöperation between the Army and the Navy is furthermore assured by the course of instruction for army officers attending the War Academy at Vienna preparatory to service with the General Staff. This course includes a series of lectures on naval topics by an officer of the Navy. Practical opportunities of realizing the benefit of this instruction is afforded by embarking the whole class on board the vessels of the Evolutionary Squadron in the Adriatic. Through such service they gain an idea of naval tactics, take part in landing operations, in laying out booms and submarine mines, and acquire an intelligent knowledge of the capabilities of battle ships, cruisers, and torpedo boats composing a friendly or hostile fleet. The officers admitted to the War Academy are taken from the line of the Army after a rigid examination in their regiments and before the Academic Board of the War School itself. The course covers a period of 2 years, and on graduation, unless immediately appointed to the General Staff, the members of the class return to service in their regiments with the certainty of assignment to fill the first vacancies in the Staff. The lectures on naval matters cover the following subjects:

(1) War ships in general; different types, qualities, and objects; construction of ships and engines.

(2) Offensive and defensive powers of a vessel; the ram, armaments, torpedoes, submarine mines, nets, booms, search-lights, etc., with remarks on double-action pumps, stoppage of leaks, and seacoast defenses.

(3) Naval personnel: Sailors, artillerymen, torpedomen, helmsmen, divers, etc.; also landing expeditions.

(4) Naval tactics: Tactical orders and formations, principal evolutions, etc.

(5) Naval warfare in general: Coast attack and defense; river expeditions; combined operations by land and sea; embarkations and landing under fire and otherwise; blockades and blockade running.

Each officer of the Navy is provided with his *war orders*, the contents of which are known only to the Ministry and himself. On the declaration of war, these orders are presented at once to his immediate superior, whose duty is to direct him to proceed promptly in obedience to them.

The coast is divided into four zones of about 460 kilometres, to each of which is assigned a flotilla, composed of depot ships, torpedo rams, and torpedo boats. The fine natural harbors of Cattaro and Sebenico are in a condition to serve as points of support to the defensive flotillas.

In addition to a portion of the regular corps, the following forces can be utilized for military and technical service on land:

(1) A category of sedentary naval officers, who form a separate branch and are recruited from officers no longer suitable in all respects for sea service. They are assigned to duty as commandants of naval fortresses, in connection with naval barracks, the Naval Academy, and the technical establishments, and as commanders of districts for the naval levy.

(2) The corps of Ordnance Engineers, which is charged with the manufacture, proving, and maintenance on land of the naval artillery material, and which is recruited partly from the abolished corps of Marine Artillery and partly from naval officers and employés who possess special aptitude for this service.

The system of raising men for active service and for the Reserves is identical for the Navy and the Army. The empire is divided into military districts. The coast districts furnish the levy for the Navy, and are governed by naval officers of the sedentary category. These districts are under the orders of the army provincial commander in all matters that relate to the levying of the men, but are under the Admiralty for administrative and disciplinary purposes.

The captaincies of the ports, the light-house and semaphore services, and the mercantile marine are under the orders of the local naval governor; a large part of the personnel is recruited from men who have belonged to the Navy or to the merchant service; the same is true for the Naval Custom Service, which also utilizes several small steam vessels employed in watching the islands and the coasts.

During war the naval officers serving on the staff at forts occupied by the Army point out the different classes of ships in sight, and thus prevent the batteries from firing upon their own vessels or upon friendly merchantmen.

Additional fortifications are now building, and in contemplation, which shall be armed with naval guns and manned exclusively by naval forces.

ENGLAND.

The coast of England is divided into nine districts, each commanded by a captain in the Royal Navy, who commands also the reserve ship assigned to the district as the central vessel of the mobile defense. The commanders of districts are subordinate to the General Superintendent of the Naval Reserves, who is an Admiral, with headquarters in London.

The districts are separated into divisions, each under a commander or lieutenant, temporarily or permanently attached to the Coast Guard. Each division is subdivided into stations, commanded by a subaltern officer of the Coast Guard borne on the Navy List, and each station is divided into guards under a petty officer of the Coast Guard.

The Coast Guard is a permanent body, recruited voluntarily from those who have served in the Navy. It maintains an active lookout along the coast for naval, revenue, and life-saving purposes and serves as a nucleus in assembling the defense during war. It is regularly exercised at gun drill and in handling boats. At each of the principal stations a battery and a drill shed are maintained for this purpose.

Besides the central reserve ship, several small coast-guard vessels are assigned to each district and cruise along the coast in constant communication with the shore stations. They are manned by coast guardsmen, who receive annual drill at great guns and small arms on board the central ship.

In time of war, the Coast Guard is reënforced by:

(1) Corps of Naval Volunteer Artillery: Enrolled during peace and drilled periodically. It is divided into brigades and batteries, commanded by lieutenants and sublieutenants of the fleet.

(2) Corps of Coast Volunteers: A reserve recruited from the sailors in the coasting trade.

The fortifications are under the control of the Army. At the naval ports they may be manned partly by naval forces; and for this reason the members of the Marine Artillery and the Marine Infantry exceed those required for the fleet alone.

The submarine-mine defense is under the charge of the Royal Engineers; but the torpedo boats are under naval control, as is the mobile defense in general. Recently the need of submarine defense for the large commercial ports and the mouths of navigable rivers has been recognized and steps for securing it have been taken. For handling this material a force of torpedo volunteers is organizing.

From time to time proposals for amalgamating the Marine Artillery with the Garrison Artillery have been under consideration, forming from these two bodies of men a special corps of Royal Artillery for coast defense not only at home but abroad. Somewhat in this spirit the Admiralty is forming the nucleus of garrisons of fortified coaling stations, in the various parts of the world, of marines; and a detachment of them have recently been put through a course of submarine mining, with a view to being drafted to Vancouver Island, to aid in its defense, in case of attack.

The entire Army quartered in England is stationed with a view of rapid concentration on the coast.

TABLE OF RANK AND COMMAND.

All officers of the Navy employed in the Coast Guard rank according to the dates of their commissions or warrants.

Coast Guard Rank.	Corresponding Naval Rank.
Chief officers of cruisers, and late of cruisers if serving on shore, as divisional or station officers.	With, but after lieutenants.
Senior mates of cruisers.	With, but after sublieutenants.
Chief officers of stations.	With, but after warrant officers.
Second mates of cruisers.	With, but after midshipman.
Chief boatmen in charge.	Chief petty officers.
Chief boatmen.	First-class petty officers.
Commissioned boatmen and divisional carpenters.	Second-class petty officers.
Boatmen.	Able seaman.

All ratings of men in coast-guard cruisers are assimilated to the Royal Navy, and they rank according to their respective ratings.

NAVAL DUTIES.

The captains of district ships are under the immediate orders of the Admiral Superintendent of Naval Reserves for the special service of the Coast Guard, for the suppression of smuggling and the protection of the revenue; and also for the purpose of drilling the men of the Coast Guard, Royal Naval Reserves, and Seamen Pensioner Reserve, as well as newly raised men and boys for general service. They are guided by the Queen's regulations, the Admiralty and Coast-Guard instructions, and circulars for the order and discipline of the ships, and of the gunboat tenders and coast-guard cruisers placed under their command.

The district ships are manned with reduced crews and are kept in an efficient state in every respect; so that in event of emergency their crews may be supplemented by officers and fleet men from the Coast Guard, and be able to assemble with the fleet, ready for active service.

Each district captain is required to consider and place on record the most expeditious manner of provisioning the ship, coaling, and procuring the necessary stores, to obviate delay in preparing the ship to keep the sea when necessary. He is also held responsible that the officers and fleet men serving under his orders are kept efficient as regards their drill, and that the order and discipline of the service be maintained as well in the Coast Guard on shore as the ship and tenders under his command.

He must inspect his district once a year, using the gunboats and cruisers as much as possible on this duty; the drill ships and batteries within his district and the gunboats and cruisers are inspected annually.

The district ships make an annual cruise for the purpose of exercising the crews in heavy gun drill and torpedo practice at sea.

During the winter months, from 1st October to 31st March, the exercises are considered as being principally for the purpose of keeping the various machines and gear in proper order, although at the same time they afford opportunities for a limited amount of instruction.

Torpedo nets are rigged twice every month; the quarterly exercises consist of two runs with Whitehead torpedo from the ship in harbor, and of one run with the same torpedo from each set of boat's gear supplied; one charge is exploded, semiannually, from each boat fitted with spar torpedo.

During the summer months, from 1st April to 30th September, every opportunity is taken to carry out torpedo exercise and instruction, more particularly when the fleet men of the Coast Guard and the Royal Naval Reserves are on board, and still more during the summer cruise of the reserve squadron.

The district ships go to sea quarterly for the purpose of exercising their crews at night quarters and to expend the allowance of ammunition, firing at a target, etc. The boats of such ships are manned and armed at least twice in each quarter.

The upper decks of district ships are covered during winter to protect the crews during drill.

The crews of gunboats and cruisers, when in the presence of the district ship, are called on board the latter occasionally for drill.

Divisional officers are responsible for the punctual execution of all orders and the performance of all duties in the divisions under their command. They reside at such places as may be ordered, and can not change their residence without permission. They are required to make themselves thoroughly acquainted with the approaches by sea to the line of coast within the limits of their divisions. When inspecting the stations in the summer, they take advantage of all opportunities to embark in the station boats for this purpose. They must inform themselves of the depths of water, rise, fall, and directions of tides, of the facilities for landing or embarking under all circumstances of wind and weather; of the ports, creeks, bays, inlets, and estuaries within their divisions; of the distances from telegraph stations, and of any other local information that may be useful in time of war. They are also required to see that the officers and men under their orders have a competent knowledge in this respect, so far as relates to the vicinity of the stations to which they are attached.

They also note at what particular stations it will be necessary to keep lookout men, and how many in each case for reporting passing vessels and for coast defense, when the Coast Guard are called out in time of war. This information is reported to the district captain on inspections.

They must visit the batteries in their divisions once a month and give a close supervision to the drills of the Naval Reserves, and must see that target practice is carried out by the latter under an officer.

Station officers must execute carefully and punctually all orders they may receive from their division officer and must see that the crew perform the duties assigned to them; report arrivals and sailings of vessels of war to the Admiralty, and the movements of district ships, gunboats, or cruisers to the Admiral Superintendent; he must also report promptly casualties to any of Her Majesty's ships, and any occurrence of great importance, although not connected with the service, which may take place on the coast.

Officers and men of the Coast Guard are maintained as the first reserve for the Navy in case of need; they are to be kept in readiness for embarkation. For the latter purpose they are formed in two sections, so that, when embarking for the annual cruise or drill, or being called out for active service, a section or a district may be drafted without denuding any particular division or station of its entire force. Half of the force embarks annually for a cruise at sea, and the other half for ten or more days of gun drill, the object being to keep the coast guardsmen and the crews of district ships thoroughly efficient in their drills.

SPAIN.

The coast of Spain is divided into departments called captaincies-general, under the orders of naval officers styled Captains-General, who command the effective naval force of all the coast in the department, including the coast guard, the fisheries and customs, and the recruiting for the Navy.

The departments are divided into maritime captaincies, and these again into districts; these subdivisions are commanded by naval officers, who, within their respective zones, are captains of the local ports, directors of naval recruiting, commanders of the local naval forces, and heads of the semaphore, light-house, beacon, and customs services. These officers belong to the active list, to the reserve, or to the retired list, according to the military importance of the zone. Subalterns are drawn from the noncommissioned officers of the navy or from pilots. These, for judicial and administrative purposes, are aided by employés of the corps of marine auditors, which has a variety of duties intrusted to it.

For the shore duties connected with local coast defense, the following personnel can be utilized:

(1) Reserve corps: This corps consists of naval officers who have

been retired on account of age or physical disability. To it are attached warrant officers and pilots who, in consideration of their services, may be promoted as high as the rank of lieutenant.

(2) Corps of Marine Artillery, employed partly on board ship and partly on land.

(3) Corps of Marine Infantry, recently organized.

(4) Naval Reserve: The Naval Reserve is organized in battalions, and is formed from the second category of the naval levy; it is called out every 2 years for 6 weeks' drill.

(5) District Naval Militia, composed of those who have already complied with their obligations in the levy.

(6) Corps of Marine Volunteers, recruited from men living on the coast, and intended not only to supply the ordinary and extraordinary naval armaments, but also to aid in the defense of the ports.

The Volunteers, the Reserve, and the District Militia are under the orders of the commanders of maritime captaincies and districts, who are also charged with their organization and instruction.

The Semaphore Service has always been under the direction of the Navy; it was reorganized, in 1872, on the French model. Its employés are recruited from the Naval Reserve and are under the commanders of the district within whose limits they happen to be. The telegraphic service and the construction of the stations are, however, controlled by the Department of Public Works, subject to the wishes of the Admiralty.

The customs, fishery, and pilot services are also intrusted to the Navy, which maintains for the purpose a coast-guard flotilla, distributed along the coast, and under the orders of the local maritime commander. The flotilla consists of steam vessels, sailing vessels, and row boats, manned by sailors, apprentices, and pilots of the Navy, belonging either to the reserve or to the retired lists.

The submarine defense is assigned to 6 companies of torpedomen—four for the Peninsula and two for the Colonies.

The former are stationed at Cadiz, Ferrol, Cartagena, and Port Mahone. There is a torpedo school for officers at Cartagena, the course covering 9 months.

To the district of Cadiz are assigned 3 torpedo boats, the personnel consisting of 1 lieutenant, 1 engineer, and 28 men; to that of Ferrol, 5 torpedo boats in reserve, the personnel being 2 lieutenants, 2 engineers, and 28 men; to that of Cartagena, 3 torpedo boats, with 1 lieutenant, 1 engineer, and 28 men; and to that of Mahone, 2 torpedo boats, under a personnel of 1 lieutenant, 1 engineer, 1 paymaster, 1 surgeon, and 46 men.

NAVAL DISTRICTS.

The three districts, at present, are those of Ferrol, Cadiz, and Cartagena. The first extends from the mouth of the Bidassoa to that of the Minho, the second from the mouth of the Guadiana to Cape de Gata, and the third from Cape de Gata to the French frontier, and includes the Balearic Islands. In addition to these there are two colonial naval stations, viz, Havana and the Philippines, with a minor command at Puerto Rico.

MARINE INFANTRY.

Although this corps may be assigned to duty on board ship, its special function is to garrison the three districts of Cadiz, Ferrol, and Cartagena.

Its effective strength is 400 officers and about 7,000 men. It is commanded by a Field-Marshal, each district being under a Brigadier-General. A Colonel commands two *tercios*, each of which comprises 7 officers and 5 noncommissioned officers at headquarters, and of 630 officers and men on garrison service.

A detachment of 130 officers and men is stationed at Madrid for duty at the Ministry of Marine.

RUSSIA.

The Russian coast is divided into maritime districts, in each of which an Admiralty official resides, who may be, also, the military governor of the district.

For purposes of defense the coast is divided into zones, commanded by the senior fortress commander or by an officer appointed by the Czar. In practice, the command of coast fortresses and their adjacent zones is intrusted to naval officers, except at points where the defense by land is of preponderating importance.

The following naval personnel is utilized for coast guard in peace and defense in war:

(1) Dockyard officials, consisting of ex-naval officers, commissioned or warrant, and of retired officers capable of discharging such duties.

(2) Ship's crews: Three divisions of sailors are assigned permanently to the coast defense and for service in the light-houses and semaphores.

(3) Naval Customs Flotilla of the Baltic: This is under the command of an Admiralty official, and, besides preventing the landing of contraband goods, looks after the light-house and semaphore service and assists vessels in distress. During peace, this flotilla is at the disposal of the Minister of Finance, but during war it is supplied with torpedoes and becomes part of the torpedo fleet. The personnel is attached to it by turns for two or three years.

A flotilla, commanded by a naval officer, and manned partly by sailors of the Navy, is engaged in passenger traffic between the Caucasian ports of the Black Sea and the port of Batoum.

(4) Torpedo miners, for submarine defense, drawn partly from Army Engineers and partly from the Navy.

(5) Custom-house officers: This corps is recruited from soldiers who have completed one year's service; they complete the period of enlist-

ment in this corps. In peace it is under the Minister of Finance; but in war it is under the control of the military authorities, who are charged also with its maintenance.

(6) Coast-Guard corps, organized at certain points of the coast for customs and guard service. It is under the orders of the chief of the customs, who is invested with military rank.

The light-house, semaphore, life-saving, and hydrographic signal services are controlled by the Navy and manned by its forces.

The mobile defense is also under the Navy.

NAVAL PORTS.

The naval ports of the empire are divided into two classes. Of the first class are Cronstadt, St. Petersburg, Nikolaiev, Vlavdivostok, and Sebastopol.

Of the second class are Revel, Sveaborg, Archangel, Batoum, Baku, Nikolaievsk on the Amur.

The administration of the first-class ports is in the hands of the Commander-in-Chief of the port at Cronstadt, of the Commander-in-Chief of the fleet and ports of the Black and Caspian Seas at Nikolaiev, and of the Commander-in-Chief at Vladivostok. The port of St. Petersburg is under special regulations. Second-class ports have commanders of their own, subject to the above commanders-in-chief.

The commanders-in-chief of first-class ports are appointed by the Czar and are directly under the Ministry of Marine. The authorities at second-class ports are of lower rank.

SUBMARINE DEFENSE.

The headquarters of this service are at St. Petersburg and Odessa. The principal stations are Cronstadt, Sveaborg, Odessa, and Sebastopol. There are 4 companies of torpedo miners, each consisting of 8 officers and 242 men.

During peace the companies are divided into detachments, which are distributed to the more important ports and are required to learn all the features of the coast in their respective jurisdictions. During winter the men receive instructions in electricity and submarine mining, and in summer they engage in practical exercises.

Large depots for submarine mines have been erected at Cronstadt and Odessa, and smaller ones at the other ports.

NORWAY.

In Norway the entire coast defense, even to the fortifications, is intrusted to the Navy, which, in case of need, is assisted by the Army.

The coast is divided into districts, commanded by naval officers, who are charged with the enlistment of recruits, their instruction, and with the command of the coast guard militia. Those belonging to the naval levy serve 3 years in the regular Navy, 4 years in the district naval militia, and 3 years more in the coast guard reserve.

The district militia and the coast-guard reserve are under an Admiral or the senior naval officer and are exercised periodically.

A permanent torpedo corps is organized for submarine defense.

There is a permanent committee on submarine weapons and another on gunnery and coast fortifications.

The semaphore, light-house, and pilot services are controlled by the Navy.

SWEDEN.

The Swedish coast is divided into departments, with headquarters at the naval ports, which are under the command of Admirals; the latter are charged with the coast defense in their own departments.

Each department is divided into captaincies or districts, governed by officers of the Naval Reserve, who command the district coast-guard companies and the boatmen or ferrymen militia.

The ports, the light-house, semaphore, pilot, and hydrographic services, and the nautical schools are under the control of the naval authorities.

For service on shore the Navy disposes not only of officers on the active list but of those who belong to a cadre of permanent reserve, which is equivalent to that of retired officers in other navies. Such officers are assigned as heads of the captaincies, commandants of coast militia, professors in the naval schools, etc. During war there is also a cadre of the second reserve, in which officers of the mercantile marine can be enrolled as subalterns after having completed a special course.

The coast-guard militia is recruited by conscription, and includes all sailors, fishermen, firemen, engineers, and inhabitants of ports. It is commanded by officers of the permanent reserve.

The boatmen or ferrymen militia is an organization peculiar to Sweden, and is maintained at the expense of land and house owners as a war and customs tax. A part of it is permanently under arms, the remainder being called out during war and for periodical drill in peace. It is organized into companies, distributed among the districts, and commanded by officers of the permanent Naval Reserve.

There is also a regiment of Marine Infantry.

COMMENTS.

The defense of a coast, and especially of a port, resolves itself into two parts—the active and the passive. The active includes gunboats, torpedo boats, and harbor-defense ships; the passive embraces submarine mines, rapid-firing guns to protect mine fields, and batteries of heavy guns.

The effective range of artillery is from 10 to 12 miles. A ship only two miles distant, especially when in motion, is a very difficult object to hit; while towns, manufacturing establishments, etc, can be bombarded at any practicable range. These facts, together with the development of rapid-firing guns, the charging of shells with high explosives, the dynamite cruiser, torpedo, and submarine boats, and electric search lights have altered entirely the question of coast defense; and even the rules existing during the Franco-Prussian war have been much modified.

If a Navy is made thoroughly competent for its work, no other defense for a coast will be called into play; and if it is incompetent, no other defense can prevent a disaster to the coast. It may, perhaps, be regarded still as a truism that real defense against heavy attack on most coasts is the old one of a reserve fleet in home waters. Thorough competency, though, to perform its work of attack and complete defense would involve, in any country, the construction of a very large fleet; and the result is that coast and harbor defense, like every other factor in war, is a matter of compromise. Every inch of coast line can not be made absolutely safe; financial considerations alone would prevent it; It is not possible, therefore, to afford protection from bombardment to all towns lying upon the seaboard. The long range of existing guns enables even a comparatively small ship to bombard a town at a distance of 4 or 5 miles.

It follows, then, that a nation can not engage in war without suffering to some part of its coast. Naturally, the chief canon of defense is the greatest safety to the greatest number. Thus, a few coast towns may represent, collectively, much wealth, and yet may be destroyed without compromising, to any great extent, the general safety of the country. On the other hand, the reduction of a port or harbor might affect a whole district, by cutting off food supplies and by giving one less place of safety and refuge to merchant vessels or one less base of operations to ships of war. It is not too much to say that the destruction of a great dock-yard might decide the issue of a great war. It is for such reasons that great ports demand in a permanent degree the protection which can be afforded, and which should be provided, during peace.

As has been seen, nearly every European power treats the question of defense of ports as a naval one; for in some cases an active naval defense is the only one which can adequately protect the port; not only this, but the entire coast defense—the land, as well as the sea part of it—is in naval hands, and the Admiral, not the General, commands it.

It is held in Europe also that such organization and system are in entire keeping with the essence of military science, which is that the responsibility for adequate preparation for war must be centralized, and can not be distributed without confusion and danger and great loss of efficiency, and that the necessary measures, when so intimately connected and interdependent, can not devolve, even in part, on two or more departments, but for efficiency and greater public safety should rest with one.

In examining the coast defense systems of the several maritime nations, the first place is due to Germany, for in that State the defense of the coasts forms part of one vast, sound, and well-considered whole, and is the subject of accurate studies and of carefully calculated arrangements. Its system is in keeping with the advance in the art of war, which, in Germany especially, has been brought about by the introduction of modern ideas of scientific and business exactness, based upon a full knowledge of the conditions under which a Navy must be used, and of the principles controlling its organization and handling. Its good results are seen not only in an excellent material and enlisted personnel, but especially in a corps of officers whose education in their art will compare favorably with the preparation which great universities offer to men who devote themselves to other professions and to the sciences.

This is the case, moreover, notwithstanding the short period which has elapsed since Germany acquired national unity and has given closer attention to the sea.

The fundamental idea in the arrangement of the naval forces has been to make sure before all else that the coast and that the rallying points and bases of operation of the fleet shall be safe from hostile attack. When this is attained, attention can be directed to extending the radius of naval action until eventually offensive action will become possible.

In apportioning the duties of the Army and the Navy in the defense of the State it is held as an unquestionable axiom that the Navy be intrusted with the entire defense of the ports and of the littoral.

In France the supremacy of the Préfet Maritime, always a naval officer of high rank, is the most important principle; the unity of the mobile and the fixed defense is thus assured, and they are placed under a head whose experience makes him familiar with their details.

In case of need sailors can be transferred to the forts and the Marine Artillery to the ships without disturbing the organization. The confusion that would arise should such a transfer be required where a part of the defense is under the Army and a part under the Navy is evident; not only are the two elements of personnel separate and distinct in organization and training, but each would have to adapt itself to the arms and material of the other service. The conditions and requirements of modern war are such that the emergency might readily occur in which the fleet could detach a force for service in the forts or with the mobile and fixed defenses, or the converse.

The central idea of the French system is that the true function of the Navy is to fight the enemy afloat, and hence that all personnel and material upon which this duty devolves should be placed under the Ministry of Marine. The coast fortifications, mobile, fixed, and submarine defenses, the search-light stations, and the semaphore service are therefore assigned to the Navy. Other considerations have supported this idea, among them the fact that France has a powerful army and extensive land frontiers; so that the Minister of War should not be burdened with the defense of the coast and the mobilization of its personnel.

In Italy and Austria there is marked agreement of opinion that for the interest of the State the coast defense should be in the hands of the Navy. The manœuvres at Spezia and Pola have proved the absolute necessity of stationing naval officers in the forts to instruct the army forces concerning the character of approaching vessels and to prevent them from firing into the mine fields.

It is held in both countries that for efficient coöperation with the fleet the coast batteries should be controlled and garrisoned by naval forces, thus assuring prompt and intelligent action; while a nautical ruse or false display of colors, which might surprise the landsmen of an army force, would not deceive sailors, who by profession are familiar with the several types of ships and are accustomed to naval manœuvres.

Italy, agreeing with Germany and France, has virtually confided the defense of her coasts in all its branches to the Navy, and Austria is following suit.

The published information concerning the Russian system is meagre in its details, but so far as is known it is controlled and operated entirely by the Navy, except at those coast fortresses where the defense by land is of preponderating importance.

In Norway and in Sweden the coast defenses, even to the fortifications, are intrusted to the Navy.

The Continental Powers have not only initiated the plan of placing all coast defense in the hands of naval officers, giving them command of maritime forts and the shores between them, but they are also developing and extending the plan. With them the idea prevails that the Army is an attacking force, which it generally has been.

In England the minds of the military authorities, and through them of the public, have been swayed by the idea that the Army is a defending force, which it has never been since the battle of Hastings, so that defense at home has been regarded as a primary duty of the land forces. In 1886, however, the question of turning over the command of the seacoast fortresses to the Navy and making the latter entirely responsible for the defense of the coast came under the very serious consideration of the British authorities, and was discussed between the War Office and the Admiralty. It is proposed by the former that the latter shall have entire control, it having come to the German and French view of the subject of coast defense.

The Admiralty, though recognizing this fact, are averse to undertaking such a charge at the present time, when they feel that at any day war may become imminent and they may not have time to perfect the organization required by such an addition to their already great administrative burdens.

A motion was made in Parliament during the past year to place the ports and coaling stations held for naval purposes under naval control. It was maintained that the present system is practically a departure from the elementary truth that the Navy is England's line of defense;

that the duty of the Navy is to prevent an attack; that for army men to perform naval duties is to place them outside their legitimate sphere of action; and that the system so far pursued has made the coast defense of Great Britain the least efficient of any of the great powers. These points have been urged by Sir William Jervois, who has had more to do with coast defense and fortifications than perhaps any other officer in the English service. This officer was one of the strongest advocates of the change proposed, if for no other reason than that its adoption "would be productive of economy through its intrinsic values of unity and simplicity;" division of authority and departmental friction—fruitful sources of inefficiency—would disappear, while the taxpayer would benefit by obtaining the best possible return for a given outlay, which is the truest economy also.

The same view is held by Sir Andrew Clark, lately Inspector-General of Fortifications. He maintains that Marines and not Regiments of the Line should garrison all English colonies, because they would perform the work better and cost less, and for the same reasons he would intrust the defense of the commercial and military ports in England, as well as the coaling stations abroad, to that force which is specially trained to fight both on land and sea.

The opponents of this policy held that it would add a large land force to the Navy, which objection was answered by saying that in this way alone can the evils arising from the present system of dual administration be removed.

A certain amount of success was accorded the motion. The experiment of garrisoning with Marines is be tried in the Falkland Islands. If successful the next place will be, perhaps, in some of the eastern colonies. It is believed that the rest will come in time if England is resolved to maintain her position as a great maritime power, which is her rôle in Europe.

In general, foreign powers recognize that unity of control is a necessity in a properly organized coast defense system, and no halfway measures are regarded as admissible. The coast lines are divided into a number of naval commands, each under a Vice-Admiral or other naval officer of high rank, who is Commander-in-Chief of the principal fortress or station, together with the adjacent coast and islands, his jurisdiction extending to the limits of similar commands on each side of his own. It is held, furthermore, that in such commands a combined force of the two military services is objectionable, and would not be productive of the greatest success; that, in spite of orders and regulations, jealousies and rivalries would exist, and obstructions would result from them; that it is easier to train new men than to eradicate old prejudices; and that the technical duties of the Artillery, Ordnance, and Engineer Corps of the Army are sufficient in detail, numbers, and importance to require their full attention and closest study and application to insure thorough efficiency and organization in their respective branches, and in the Army as an entity, without imposing upon them the burden of coast defense in addition. The Artillery evacuates the forts and becomes occupied with its exercises and functions for field and siege service; the Ordnance Corps superintends the manufacture, supply, and care of army ordnance and equipment proper; and the Engineers pursue their technical duties as such, nothing being taken from them by this system except the submarine defense, to which they have no claim from their particular sphere or training. Where needed, officers of the latter Corps are detailed for special work with the local naval defense, as in Italy, and while so detailed are under naval control.

The coast defense systems of such powers are thus purely naval in organization, administration, and control, or are rapidly becoming so.

VIII.

SERVICE HIGH EXPLOSIVES.[*]

By Ensign EDWARD SIMPSON, U. S. Navy.

The term *explosive* is applied to those substances, solid or liquid, which upon the application of heat or shock, are converted, either by combustion or decomposition, into gases having many times the volume of the original substance. The violence of the explosive effect depends on (1) the volume of the gases so evolved; (2) the rapidity with which they are formed; (3) the amount of heat generated, as influencing the volume of the gases evolved.

Explosives are either mechanical mixtures or chemical compounds. Gunpowder is the representative of the former type in which the molecules of the ingredients are mechanically mixed in close contact; and nitro-glycerine is a representative of the latter type, the atoms of the different elements being chemically combined in the molecules of the explosive. In the former, or gunpowder type, explosion is caused by combustion being communicated progressively throughout the mass, the ingredients uniting under the influence of heat to form the resulting gases. In the latter type, each molecule holds in combination the elements required to produce the gases, and are so sensitively balanced that, when influenced by a certain shock, they are instantaneously converted into these gases.

Explosives of the gunpowder type are known as the *low explosives*, and by reason of their progressive action, which can be regulated by mechanical treatment to fulfill different required rates of combustion, are used as propellants. They are exploded by ignition.

Explosives of the other type have received the name of *high explosives*, and it is with them that this article has to deal. From their extremely rapid decomposition, and large volume of gases generated, they are used where shattering or rending effects are required. They are exploded by detonation.

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[*] In the preparation of this article, in addition to various other sources, the works of the following authorities were consulted: Gen. H. L. Abbot, Sir F. Abel, Commanders F. M. Barber, and A. S. Barker, Maj. J. T. Bucknill, Mr. P. F. Chalon, Maj. J. P. Cundill, Messrs. W. H. Deering, M. Eissler, and C. N. Hake, Prof. V. B. Lewes, Col. V. D. Marjendie, Prof. C. E. Monroe, Mr. P. F. Nursey, Lieut. Col. N. L. Walford, Maj.-Gen. W. H. Wardell, and Capt. E. L. Zalinski.

Detonation is an explosion in which the second condition of the violence of an explosive effect, mentioned above, reaches a maximum; in other words, when the decomposition takes place without perceptible lapse of time. It was discovered by Nobel in 1864, and is produced by the explosion of an initial charge placed as nearly as possible in contact with it, which, through shock or heat, sets up a certain chemical change amongst the particles of the mass, causing it to be immediately transformed into many times its volume in gases. Heat alone, also, may produce detonation.

That certain detonators are not suitable to all explosives is well illustrated by the fact that gun-cotton will detonate nitro-glycerine in close proximity to it, but nitro-glycerine will not detonate gun-cotton. But all high explosives can be detonated by fulminate of mercury, and some by it only; and consequently it is accepted as the best detonating agent known. It is very dense, and when subjected to a heat of 360° F., to shock, or friction, it decomposes with the utmost rapidity. It is not so much the volume or heat of the gases evolved, as it is the shock occasioned by this intensely rapid decomposition which causes detonation to the explosive; but, as it is very local in effect, it must be in contact to develop its full power.

Although explosives are more difficult to detonate with a fuze when compacted than when in a loose state, still they must be sufficiently held together, either by the introduction of an inert mass or by confinement or compression, in order to obtain a detonation of the first order; for the fulminate, upon explosion, tends to scatter the explosive, as well as to detonate it. This is shown by the fact that gun-cotton is detonated with more force when compressed than when in the loose state, but it requires a stronger detonating charge.

All explosives are liable to detonate by influence; that is, by the explosion of masses of the same or some other explosive near them.

The velocity of transmission of detonation was found by Abel to range from 17,000 to 20,000 feet per second for continuous slabs of gun-cotton, and from 19,500 to 21,500 feet per second for dynamite. Mr. C. N. Hake strikingly illustrates the great rapidity of detonation by stating that a ton of dynamite, stretched out in a cord seven-eighths of an inch in diameter and a mile in length, detonated simultaneously at both ends requires one-fourth second to be consumed, while if lighted it requires several seconds.

Experiments show that the waves of detonation through an explosive mass act from the initiative charge, and that to obtain the best effects the fulminate should be placed on the side away from the opposing force. Two 10-pound charges of dynamite were exploded against the face of a vertical iron plate 1 inch thick, producing holes of 96 and

192 square inches when the fuzes were on the sides next to or away from the plate respectively.

Detonators, as generally used, consist of fulminate of mercury put up, in quantities depending on the strength required, in metallic capsules, and are exploded either by friction, percussion, or heat of a match or electric wire.

In 1845 Schönbein discovered gun-cotton, and in 1847 Sobrero discovered nitro-glycerine; but the full value of these explosives was not developed until 1864, when Mr. Nobel discovered that they were capable of being detonated, producing an explosion, the effect of which was far in advance of any then known. Since then numerous high explosives have been patented and tried with varying success, Cundill's Dictionary of Explosives describing 348, which are divided as follows:

Class.	Class.	No.
I	Gunpowder	16
II	Nitrate mixtures	63
III	Chlorate mixtures	67
IV	Nitro compounds containing nitro-glycerine	82
V	Gun-cotton and other nitro compounds	64
VI	Picric powders	11
VII	Sprengel explosives	5
VIII	Miscellaneous, including fulminates	40

Some of these have never been practically used, others are suitable for mining purposes only, and but few have as yet proved a decided adaptability to military purposes.

The properties of Class I are too familiar to require any description. As a propellant gunpowder still holds first place, but as an explosive its force is so inferior to that of the high explosives that military demands require a substitute in its stead.

Class II is closely allied to Class I; in it other nitrates are substituted for that of potash, giving a more rapid or slower rate of combustion as they contain more or less oxygen. But as they are hygroscopic they are not suitable for military purposes.

All the mixtures in Class III contain chlorate of potash, a substance which produces a very powerful explosive. But it is extremely sensitive to percussion and friction, which increases with time and hydroscopic variations, and it is liable to decompose when brought in contact with acids. Explosives of this class are, as yet developed, too sensitive for military uses.

To Classes IV and V belong those substances containing carbon and hydrogen which are acted upon by nitric acid or a nitrate and sulphuric acid. They include the nitro-substitution compounds such as nitro-benzoles, in which the hydrogen of the benzole is replaced by nitrogen and oxygen; the nitric esters, gun-cotton and nitro-glycerine in which the oxygen of the cellulose or glycerine unites with the nitrogen of the nitric acid; the dynamites in which nitro-glycerine is mixed with either an inert or active base; and the gelatine compounds which include various mixtures containing nitro-cellulose. In 1832 Barconnet invented xyloidine by treating starch, woody fibre, etc., with concentrated nitric acid; in 1838 Pelouze and Dumas experimented with paper and vegetable substances; in 1845 Schönbein manufactured true guncotton; and in 1847 Sobrero discovered nitro-glycerine. Since then this class of explosives has been experimented with and improved upon with such degrees of success that it now includes the most powerful known explosives; many of them possess, when manufactured of pure ingredients, good keeping and safe handling qualities; they are capable of being kept for long periods at temperatures under 120° F.; some are insoluble in water, and some are insensitive to shock. For service uses blasting and explosive gelatine, carbo and No. 1 dynamite, forcite, guncotton, nitro-glycerine, and tonite have been subjected to tests, and several have been adopted by different governments.

Class VI forms a subdivision of Classes IV and V, being a nitro-substitution compound. Picric acid is produced by the action of nitric acid on carbolic acid, and when mixed in combination with a metallic oxide or nitrate, under the influence of heat, forms a picrate, potassium and ammonium picrates being the only ones used in explosive preparations. In 1869 Désignolle introduced a mixture of potassic picrate and saltpetre for bursting charges for torpedoes and shells, and in 1870 Abel substituted ammonium picrate for the potassium salt. The first mixture, while being as powerful as nitro-glycerine, is very sensitive to percussion, heat, shock, and friction, partaking of the properties of Class III. Abel's mixture is an improvement over it, not being so susceptible to friction or percussion; but all the picrates explode when subjected to heat of sufficient intensity and duration. During the Franco-German war, 1870–71, by order of General Rivières, small shells and hand grenades were filled with a picric acid compound. These were very effective in blowing down outside walls, but were found too destructive when used indoors for opening communications through the walls of adjoining houses.

In 1873 Sprengel showed that picric acid alone was subject to explosion by detonation, and Turpin, who patented this quality in 1885, showed that dry powdered picric acid could be detonated by a weight of 1 pound falling 26 inches. This sensitiveness is increased by warming, but picric acid will not explode by simple ignition or heating. It requires a primary charge of fulminate, a picrate, or confined ordinary gunpowder placed within it to produce detonation; but detonation so produced is communicated from dry to wet masses, containing as much as 17 per cent. water, and also to separate masses with intervening spaces distant according to the size of the initial detonation. When picric acid is brought into contact with a metallic oxide at a high temperature, a picrate is rapidly formed, which, when heated, will explode and detonate any quantity of picric acid in contact with it. Several of the picric powders have been extensively tested for military uses, the most prominent being emmensite, lyddite, and melinite.

Class VII includes those explosives in which two non-explosive constituents, either solid or liquid, are mixed at, or just before, the time they are required for use, and form a violent explosive mixture. They include mixtures of nitric acid with nitro-benzine, picric acid, and nitro-naphthaline, and a variety of substances mixed with chlorate of potash. The fact that the constituents are non-explosive when separated makes their safety in storage and trans portation a very valuable quality for military use. All explosives of this class require detonators to explode them, but when nitric acid is one of the constituents great care must be taken that it does not come in contact with the fuze. Bellite, hellofite, and roburite are explosives of this class.

The value of a high explosive varies according to the effect desired to be produced, different explosives best suiting different conditions. For service uses, where a variety of qualities are demanded, the following are selected for discussion: Bellite, blasting and explosive gelatine, dynamite No. 1 and carbo, ecrasite, emmensite, forcite, gelatine dynamite, Gruson's mixture or hellofite, gun-cotton, lyddite, melinite, nitro-glycerine, roburite, and tonite.

Bellite is an explosive of the Sprengel type, discovered by Mr. Carl Lamm, of Stockholm. It consists of ammonium nitrate and dinitrobenzole, which, when melted at 80° or 90° C., are mixed with saltpetre When pressed warm it is almost non-hygroscopic, absorbing only 2 per cent. of moisture; and when pressed into a granular state, which best suits military purposes, it has a specific gravity of from 1.2 to 1.4, and can be exploded by a small quantity of fulminate, even if only covered by a thin sheet of tin. When presssd into hard cakes it requires a stronger detonator and closer confinement. Heated in an open vessel it begins to separate before a temperature of 200° C. is reached. It can be exploded by a detonator and by the shock of a 59-pound weight falling 5 feet. It can be stored without danger of decomposition, and has successfully withstood severe tests proving it can not be exploded by fire, friction, or vibration.

Blasting gelatine was invented by Nobel in 1879, and is composed of finely divided nitro-cotton dissolved in nitro-glycerine at a temperature of 100° F., the effect of the combination being to supply the requisite amount of oxygen to insure complete combustion. It contains from 93 to 95 per cent. of nitro-glycerine, being more and more gelatinous in proportion to the quantity of nitro-cotton, the thinner being the more susceptible to detonation and liable to liquefy and exudiate. When slowly heated it detonates at 400° F. It is less sensitive to blows than either nitro-glycerine or gun-cotton, and requires a strong detonator and close confinement to develop its full force, not being sensitive to detonation by influence. It is unaffected by water, and is more sensitive when in a frozen state. Pure ingredients are essential to insure its stability. It freezes at a relatively low temperature and is then more sensitive to explosion by concussion.

Explosive gelatine is Blasting gelatine with the addition of a certain amount of camphor, its sensitiveness depending on the amount. The proportion generally used is nitro-glycerine 89 per cent., nitro-cotton 7 per cent., and camphor 4 per cent. It burns at 570° F., requires special strong detonators or ordinary detonators with gun-cotton or dynamite primers, and is less sensitive than most of the high explosives. It is insensitive to shock, rifle balls having been fired into it at short range without exploding it, and it is believed to be as stable as gunpowder when manufactured of pure ingredients. It is unaffected by immersion in water.

Dynamites are explosives in which 75 per cent. nitro-glycerine is absorbed by some porous substance, thus rendering it safer to handle and less liable to explosion from shock. They are of two classes, viz: (1) those with an inert base; and (2) those with an explosive or combustible base.

Dynamite No. 1 is the one most commonly used and belongs to the first class, consisting of nitro-glycerine absorbed by kieselguhr, or rotten stone, from which the water and organic matter are driven out, in the proportions of 75 per cent. nitro-glycerine and 25 per cent. kieselguhr. It can be detonated by shock, influence, metallic gunpowder fuze, or detonator, its sensitiveness increasing with temperature, and it explodes at 360° F. It freezes at 40° F. and remains frozen at a considerably higher temperature, in which state it is insensitive to shock, being unaffected by rifle bullets fired into it, but is more susceptible to explosion by ignition. Great care is necessary in thawing it, as the records of mining accidents show that 95 per cent. of them are caused by this operation. Frozen cartridges are not susceptible of detonation, but loose and granular dynamite, even when frozen, can be detonated, its violence being diminished. Compacted it is more sensitive to explosion by ignition than when loose, and water disintegrates it. In tropical countries it loses its strength by gradual evaporation of the nitro-glycerine. Herr Edward Liebert and Baron von Dahmen have produced so-called safety or nonfreezable dynamites. Liebert's invention consists in adding a small per cent. of isoamylic nitrate either to the nitro-glycerine itself or to the dynamite, but the substance Dahmen uses is not known. This latter explosive, after being subjected to a temperature of from −20° to −15° C. for 24 hours, remained perfectly plastic, exploded with almost as much force as ordinary dynamite, and also by influence. Under ordinary temperatures it is less sensitive to shock than ordinary dynamite and is slightly stronger.

Carbo-dynamite, invented by Boreland and Reid, belongs to the second class of dynamites, and consists of 10 parts of specially prepared cork carbon containing 90 parts of nitro-glycerine. The complete combustion of the base with the excess of oxygen of the nitro-glycerine adds to its explosive force, and it is said to possess superior qualities to Dynamite in respect to safety in handling and transport. It does not disintegrate or exude when exposed to the action of water. Its specific gravity is 1.5.

Ecrasite is the new Austrian explosive invented by Kubin and Siersch. It has been patented secretly, and its composition is not known. It is supposed to be Blasting gelatine treated with sulphate or hydrochlorate of ammonia, or both, and it is reported to be as well adapted for use as a propellant in small arms as for a bursting charge in shells. It is said to be one and one-half times as powerful as Dynamite and to be in no way sensitive to mechanical or atmospheric influences.

Emmensite was invented in 1888 by Dr. S. H. Emmens and belongs to the picric powders. The compounds bearing the name Emmensite all contain a nitrated carbolic acid which is produced by dissolving, at a gentle heat, an excess of commercial picric acid in concentrated fuming nitric acid (50° to 52° C.), the solution, on evaporation, depositing it in yellow prisms. These prisms are heated in a dish until they become semi-liquid, and are then mixed with a mineral salt, some other ingredient being added for special purposes. There are four grades, the best, No. 1, consisting of equal weights of the nitrated carbolic acid, nitrate of soda, and nitrate of ammonia. The cake so produced is then pulverized in a mortar, the smaller the grains the more rapid being the explosive action. When heated it melts into a resinous state without exploding, and a match ignites it with great difficulty. When struck by a hammer on an anvil, or a rifle bullet at short range, only the part immediately in contact explodes, and it has been fired as a projectile from small arms against iron plates without exploding on impact, thus proving its insensitiveness to shock. Its keeping properties have been put to a 2 years' test without its deteriorating, and when mixed with some substance to act as a reducer it can be used as a propellant. Its specific gravity is said to be 1.8. Although it is hygroscopic its strength is but slightly affected by repeated saturation with water and drying.

Forcite was invented in 1880 by Capt. J. M. Lewin, of the Swedish service; it closely resembles Explosive gelatine, cellulose being used instead of nitro-cellulose, the danger involved by using that of impure quality being thus averted. Cotton is thoroughly cleansed by being alternately treated with acids and alkalis, and when in a powdered state is reduced to a jelly by steam and then treated with nitro-glycerine. No. 1 Forcite contains 95 per cent. nitro-glycerine, and other grades contain from 25 to 85 per cent., incorporated with a mixture of nitrate of soda coated with molten sulphur and wood tar, to which 1 per cent. of wood pulp is added. It burns in the open air, explodes in confined places, water has no action on it, and General Abbot considers it the most powerful under-water explosive in the market. Nitro-glycerine can not be separated by sulphuric ether or alcohol, but at 100° F. it exudes slightly, and its stability is still questioned. All grades can be detonated by 24 grains of fulminate.

Gelatine dynamite consists of Blasting gelatine mixed with some substance acting as a reducer, such as cotton, charcoal, wood, meal, etc. It contains about 80 per cent. of explosive, and, while possessing the general characteristics of Blasting gelatine, is less powerful than it but more so than Dynamite No. 1.

Hellofite, which is practically the same explosive as *Gruson's Mixture*, is an explosive of the Sprengel type, consisting of an admixture of nitrate of petroleum, or tar oil, with nitric acid. Gruson keeps the two constituents separated until, or just before, the explosive mixture is required for use, in which state they are perfectly safe to handle, transport, stow, etc.; but for commercial purposes it has been found better to mix the ingredients at the factory, but, it being then in a liquid state, decomposition and corrosive action add to the dangers of handling, stowage, etc. When mixed, it has a specific gravity of 1.4. It is rendered inexplosive when mixed with water.

Gun-cotton was first manufactured by Schönbein in 1845, but proved dangerous to handle until it was rendered safe by the method of purifying, pulping, and compressing it. It is produced by the action of sulphuric and nitric acids on cellulose in the proportion of three parts of sulphuric to one part of nitric acid. Under the action of these acids, according to their strength and methods employed, trinitro, binitro, and mononitro cellulose are produced, Gun-cotton being the first named, viz: trinitro cellulose. It is only soluble in acetone; unconfined and ignited, it burns away rapidly, or struck by a hammer on an anvil part of it explodes, the remainder being blown away; when heated to a certain temperature it explodes, and when confined or compressed, it explodes from shock, heat, or detonation. It detonates by influence.

To Mr. E. O. Brown is due the credit of discovering that wet uninflammable Gun-cotton is capable of being detonated by a strong fulminate detonator, or an ordinary detonator with a priming charge of dry Gun-cotton, the size of which depends upon the percentage of water contained. This discovery greatly increases the value of Gun-cotton as a military explosive, not only for submarine work, but also as an explosive for shells; for wet Gun-cotton is not affected by shock, failing to explode when penetrated by rifle bullets, or when loaded in shells upon shock of discharge; is comparatively insensible to sympathetic explosion, and is not exploded by heat. In 1871 the English Government tested this last named quality by burning in bonfires two lots, of a ton each, of Gun-cotton, containing 30 per cent. moisture. In one case the explosive was in discs in a closed tank, and in the other it was divided among eighty closed packages. In both cases the Gun-cotton burned away without explosion.

Steps have been taken to coat discs of wet compressed Gun-cotton so as to enable it to retain its constituency by preventing the moisture from evaporating, and decomposition taking place. In 1883 Von Forster and Wolff patented dipping Gun-cotton in acetic acid for a few seconds which dissolves the cotton on the surface and forms a coating. But this was found to crack, so they now coat the disc with paraffin, and only treat the hole in this manner to facilitate detonation. Schulhof has patented a so-called weatherproof Gun-cotton which is said to possess non-hygroscopic qualities, to be insensible to shock or blow, and to be capable of exploding by detonation or heat of over 300° F. He impregnates dry Gun-cotton with molten tallow or mutton fat, and getting rid of the superfluous grease by pressure and washing with bisulphuret of carbon and benzine.

Lyddite is supposed to be the original melinite. It was patented by Turpin, and Armstrong is said to have bought the patent rights. It is believed to be a picric acid compound composed of chloro-picrin, chloride of picryl, naphthaline, iodo, dinitro, and other phenols. It requires confinement to develop its full force, and is authorized in England as safe to handle. The properties attributed to picric acid hereinbefore mentioned are believed to relate to this explosive also.

Melinite, so named from *meli*, honey, the color of picric acid, is a picric compound manufactured at the military laboratory at Bourges, France. Since the French Government bought Turpin's patent they have added other substances to it which have had the effect of rendering it insensible to shock and friction, and safe for handling and storage. Its composition is believed to be fuzed picric acid mixed with gun-cotton dissolved in ether and compacted into granules. Other ingredients, stated by different authorities, are gum arabic and chlorate of potash. It is exploded by a detonator, and upon explosion produces large quantities of poisonous carbonic oxide gas. Its specific gravity is said to be 1.7.

Nitro-glycerine was discovered in 1847 by A. Sobrero, and is a nitric ester produced by the action of nitric and sulphuric acids on glycerine. In order to insure stability and reduce its sensitiveness to shock to a minimum, no cheap materials should be used in its manufacture; the glycerine should be above proof, the nitric acid of a specific gravity of 1.5, and the resulting explosive carefully washed to remove all traces of free acid. When ignited in small unconfined quantities it burns, but with close confinement it explodes either by ignition or when heated to 257° F. It freezes at 40° F., in which state its sensitiveness to concussion and detonation is very much reduced. It can be detonated by shock, gunpowder fuze, or detonator, generating six times as much gas as gunpowder which is expanded by the great heat produced to occupy thirteen times the volume. It is insoluble in water. Its use is now generally confined to the dynamite and gelatine forms. Cundill's rough test for determining if a liquid oozing, or capable of being squeezed from a compound is Nitro-glycerine, is to place a drop on blotting paper;

if it is Nitro-glycerine it will leave a greasy stain on drying; struck with a hammer on an anvil, or warmed gradually over a flame, it will give a loud report; lighted, it will burn with a greenish flame and give off a crackling sound. His chemical test is to shake up some of it in a test tube with pure methylic alcohol; filter the mixture and to it add pure water; if Nitro-glycerine is present a milky appearance will be produced, the Nitro-glycerine eventually settling down to the bottom.

Roburite is an explosive of the Sprengel type, invented by Dr. Carl Roth, in which the two solid ingredients, chlorinated dinitro-benzole and ammonium nitrate, are mixed together. Each in itself is non-explosive, and when ground together in a coffee grinder the mixture has successfully withstood severe tests of shock, friction, and heat. When wetted it can be dried without reducing its strength, and it is stated that it can be stored and handled safely. It requires a strong detonator to explode it, and experiments show it to be less powerful than Blasting gelatine, and more so than Gun-cotton.

Tonite is a compound of Gun-cotton and nitrate of baryta, and is made in two grades; equal parts of each ingredient are used in No. 1, which is the quickest acting and best suited to service purposes. The nitrate supplies sufficient oxygen to insure complete combustion. It burns slowly, has withstood severe tests of heat and the shock of rifle bullets fired into it, and when wetted can be dried in the sun without deteriorating; moisture, however, does not affect its strength. It requires a strong detonator.

The increased destructive effects produced by the great local action of high explosives over the low explosives, were first utilized for service purposes in mines and torpedoes for submarine use. In addition to their great power, many of them are unaffected by water; strong envelopes are not required, weak ones producing better effects, and the initial pressure upon explosion is uniform in all directions. But in order to be fully successful for military submarine use, an explosive should possess the following requirements: (1) Stability, both as regarding time and changes of temperature and hygroscopic conditions, so as to remain unaltered under any climate and during any length of stowage. (2) Unaffected by water. (3) Safety in handling and transportation, and non-sensitiveness to shock, especially when used in over-water discharges. (4) Non-sensitiveness to detonation by influence, especially when used in a system of mines. (5) Detonation should not be too quick in its action, so as to allow time for the full force of the explosion to be effected, water being slightly compressible. (6) Great density, so as to decrease bulk for a required effect. (7) Prepared for use in a convenient form for handling.

The best destructive effects are produced when the explosive is in contact; but if this is not practicable the object at which destruction is aimed should be in the line of least resistance, in which direction the greatest shock is produced by the expanding gases. Bucknill states that during experiments no iron vessel of the strength of a modern war vessel has been fatally injured when she lay outside the water crater.

General Abbot's experiments lead him to believe that in order to fatally wound the bottom of a vessel of the *Hercules* type, an explosive must produce a pressure of 5,500 pounds per square inch; that 6,500 pounds per square inch would be fatal to an ordinary double-bottomed ironclad; and that 3,000 pounds per square inch exceeds the limit of safety of a strong wooden vessel. Bucknill considers 12,000 pounds per square inch as necessary in the first case, and in a similar proportion this would necessitate 6,545 pounds in the case of a wooden vessel.

The most suitable explosives for submarine use are: Bellite, Carbo-dynamite, Dynamite No. 1, Explosive gelatine, Forcite, Gelatine dynamite, Gun-cotton, Nitro-glycerine, Roburite, and Tonite. Assuming Dynamite No. 1 as 100, Abbot and Bucknill give the relative strengths under water of certain ones of them, per pound, as—

Explosive.	Strength.	
	Abbot.	Bucknill.
Blasting gelatine	142	142
Forcite gelatine	183	133
Gelatine dynamite	....	123
Dynamite No. 1	100	100
Gun-cotton (dry)	....	100
Gun-cotton (wet)	87	80
Tonite	....	85
Nitro-glycerine	81	....
Gunpowder	20 to 50	25

Bellite, at distances varying from 17½ to 12½ feet under water, has proved itself from 10 to 15 per cent. more effective than Gun-cotton. Carbo-dynamite is said to be superior to Dynamite No. 1 in explosive power; and Roburite, when tested on land, has shown an explosive effect inferior to Blasting gelatine, and superior to Gun-cotton.

Using these respective relative strengths and assumed necessary pressures, Bucknill and Abbot have arrived at the following relative horizontal distances and charges necessary to inflict a fatal blow on a modern ironclad:

BUCKNILL.

Distance in feet	2.5	5	10	20	30	38	40	45	47	50	52	54	60	67	78	90
	Lbs	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*	*Lbs*
Blasting gelatine	4.7	23.5	75	177	274	....	369	....	....	465	484	500	600	....	....	900
Forcite gelatine	5.1	25	80	188	293	....	395	....	....	496	....	....	....	....	....	....
Gelatine dynamite	5.4	27	87	196	316	....	427	....	500	537	558	....	....	....	900	....
Dynamite No. 1	6.6	33	107	251	389	500	525	600	....	660	687	....	....	900	....	....
Gun-cotton	6.6	33	107	251	389	500	525	600	....	660	687	....	....	....	....	....
Gunpowder	26.4	132	428	1,004	1,556	....	2,100	...	....	2,640	....	....	....	....	....	....

ABBOT.

Distance in feet	3.3	5	10	14.7	16.3	19.5	20	30	31.7	35	40
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Blasting gelatine	......	4	17	......	......	......	67	160	......	......	311
Dynamite No. 1	......	......	......	......	100	......	......	......	......	500	......
Gun-cotton	......	......	......	100	......	......	......	......	500	......	......
Gunpowder	100	......	......	......	......	500	......	......	......	......	......

These tables show a marked difference in opinion as to the weights of different explosives required, but Colonel Bucknill claims the practical results obtained by the experiments of the English on the *Oberon*, the Danes and Swedes at Carlskrona, and others by the French and United States Governments, go to prove his theories. It may be of interest to compare these tables with the charges adopted by the French and Italian Governments for ground mines as the results of their experiments, the Italians considering their charges effective for a horizontal distance of 25 feet:

FRANCE.

Depth of water, in feet	26–36	50	60	67	73	[illegible]
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Gun-cotton	550	660	880	1,100	1,320	1,540
Gunpowder	2,200	3,300	4,400	......	......	......

ITALY.

Depth of water, in feet	16½–26¼	26¼–36	36–49¼	49¼–59	59–65½	65½–72½
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Gun-cotton	440	440	880	880	1,100	1,320
Gunpowder	1,100	2,200	3,300	4,400	......	......

The advantage gained for the explosive by having the vessel in the line of least resistance is well shown by Abbot's table, showing effective horizontal and vertical striking distances, viz:

	100-pound charge.		500-pound charge.	
	Horizontal.	Vertical.	Horizontal.	Verti
	Feet.	*Feet.*	*Feet.*	*Fe*
Blasting gelatine	18.2	20.3	39.1	7
Dynamite No. 1	16.3	18.6	35.0	9
Gun-cotton	14.7	17.3	31.7	3
Gunpowder	3.3	3.3	19.5	5

But all of these results may be very much influenced by the disposition of weights and internal arrangements of the vessel. In the Italian experiments with a model of a triple bottom, 75 pounds of Gun-cotton exploded in contact broke through two of them, but when the space between the two inner ones was filled with coal, only the outer bottom was injured.

It is seen from the tables above that Blasting gelatine is recognized by both authorities as the most powerful explosive.

So far as stability is concerned, that of Bellite and Roburite, they being of the Sprengel type, seems to be assured. The gelatine class is still open to question, but when pure ingredients are used in their manufacture their stability seems to be good. It is in this quality that Forcite seems to have the advantage over Blasting gelatine. Dynamite loses strength by the evaporation of Nitro-glycerine. Pure Gun-cotton, whether wet or dry, is unaffected in stability by moderate changes of heat, even when kept for long periods, and with the exception of the Sprengel type, it probably excels the other explosives in this quality.

The explosive properties of Gun-cotton, Forcite, and Gelatine dynamite are unaffected by water. Dynamite loses 6 per cent. of its power when drowned in water. Blasting gelatine, after long immersion, changes its color slightly, but does not deteriorate; and Carbo-dynamite is stated to have been immersed for eight months without being affected. Nitro-glycerine is insoluble in water; the explosive effects of Forcite are the same whether it is dry compressed or wet granulated; Roburite is affected by damp, but Mr. Lay has nevertheless adopted it for use in his torpedo; and Bellite, from its resemblance to Roburite, probably is similarly affected. We thus see that the requisite of being unaffected by water is fulfilled by several of the high explosives.

With regard to safety in handling and transportation and non-sensitiveness to shock, the value of the Sprengel-type explosive, Bellite, and Roburite is apparent, so long as the ingredients are kept separated. Dynamite and Nitro-glycerine are the most sensitive, and Carbo-dynamite is said to possess superior qualities to them. Gelatine dynamite is less sensitive than Dynamite, but should not be exposed to the tropical sun; and Forcite, while possessing superior qualities to those above mentioned, can be exploded by the impact of musket balls at short range. Tonite and Explosive gelatine have proved themselves very safe explosives and incapable of being exploded by shock or friction; but wet Gun-cotton is generally accepted as the safest known explosive.

Gun-cotton is more liable to detonation by influence when dry than when wet, and Dynamite when compressed than when loose. Gelatine dynamite and Blasting gelatine are less sensitive than Dynamite No. 1, Blasting gelatine bouyant mines of 500 pounds requiring 456 feet spacing, while wet Gun-cotton requires 321 feet, and gunpowder 100 feet. Forcite resembles Blasting gelatine, and in experiments made by Abbot, three-fourths pound charges were placed at 20, 14, 10, 8, 6, and 4 feet from an initial charge of 1 pound of Dynamite, and all failed to explode by sympathy, and one such charge, placed at 3 feet distance exploded. Dynamite under similar circumstances explodes at 20 feet. Zalinski considers that the explosion of 100 pounds of Blasting gelatine will cause sympathetic explosion to all charges within a radius of 50 feet. Bellite has withstood several tests of explosions of other masses near it, and Roburite and Tonite, requiring strong detonators to explode them, probably possess this desired quality to a greater or less extent.

Water being slightly compressible, an explosive should not be too quick in its action in order to allow time for its full force to act; hence quicker detonation in the air does not denote greater destructive effects under water; but an explosive should be quick enough to produce shattering rather than rending effects. Nitro-glycerine is too quick in its action and Dynamite too local, being less effective than Gun-cotton when exploded at a distance. Roburite is lacking in local effect, and wet Gun-cotton is more powerful than dry Gun-cotton or Dynamite. Blasting gelatine and the Nitro-gelatine derivatives are slower acting than Dynamite but more local than Gun-cotton, and, producing a great shattering effect, they probably excel it in this quality.

The specific gravities of the explosives under discussion are:

Bellite	1.2–1.4	Gun-cotton (dry)	1.06
Carbo-dynamite	1.5	Gun-cotton (wet, 25 per cent. water)	1.32
Dynamite No. 1	4.6	Nitro-glycerine	1.6
Blasting gelatine	1.54	Roburite	(?) 1.4
Forcite	1.51	Tonite	1.28
Gelatine dynamite	1.55		

And from the table it is seen that Nitro-glycerine and Dynamite No. 1 are the heaviest ones; but that the gelatines are only slightly inferior to them, Gun-cotton being decidedly deficient in this quality, which permits of heavy charges being contained in fixed capacities.

As prepared for use Roburite is in powdered form, Bellite is granulated, and Dynamite is either granular or in cartridges. Tonite is also put up in the form of cartridges. The gelatines are plastic, of the consistency of honey, and are therefore more convenient to handle, shaping themselves to the containing vessel. Gun-cotton can be compressed to any desired shape, and when wet, can be cut or sawed at will.

Summing up, we find Blasting gelatine and Gun-cotton as the two explosives best fulfilling all the requirements, and they are the ones generally in use for submarine work. Blasting gelatine shows a superiority with regard to strength, shattering effects, plasticity, and specific gravity; but Gun-cotton, from its stability, safety, and capability of exerting its full force, even when confined simply in a net, combined with its high standing in the other requirements, all tend to make it probably the best high explosive for naval use. Forcite and Bellite probably stand next in order of superiority.

Experiments in England have shown that with a ship of the *Hercules* type, with double bottom empty and coal bunkers full, 95 pounds of Gun-cotton exploded in contact will sink her, 220 pounds at 30 feet horizontal distance inflicted no serious damage; and 500 pounds at a horizontal distance of 100 feet will probably seriously damage the pipes and machinery. Wet Gun-cotton, in addition to the fulminate primer requires about 1 pound dry Gun-cotton disks to cause an explosion of the first order.

As the utility of High Explosives in warfare became better recognized, the desirability of regulating their sensitiveness, so as to enable them to be projected through the air, became very apparent. The various dirigible and auto-mobile torpedoes carry large charges of explosives, but they are limited as to range and accuracy, and, being self-destructive, are costly.

The first successful steps toward accomplishing this problem were where charges of High Explosives were projected at low initial velocities and moderate ranges, as by the Zalinski pneumatic gun; but the power of projectiles so discharged which contain 60 per cent. weight of explosive, is limited to torpedo effect, countermining, effect of high-angle fire, and injury to unprotected sides or exposed sloping decks.

This was a great step, but progress required a still greater advance. Direct fire and penetration are desired; and in order to increase the danger space it is necessary to reduce the height of the trajectory, and therefore increase the initial velocity which increases the range. To accomplish the penetration of modern armor, armor-piercing shells, with very thick walls, must be used; and as the space containing the bursting charge is proportionately reduced the necessity of a more violent bursting charge than gunpowder, and one that is not so liable to explode by the heat generated before perforation, is evident.

For use against exposed bodies of men gunpowder is still an excellent agent, being less local than the High Explosives and not breaking the shell into such small fragments, it being maintained that to disable a man a shell fragment should weigh not less than 1 ounce and have a velocity of 500 f. s., which is equivalent to one-eighth foot ton. The High Explosive, however, in addition to its great moral effect is capable of throwing pieces of the shattered projectile to the rear, which principle is used by the Germans against men protected by bomb proofs.

As explosive charges for thick armor-piercing (a. p.) shells, or for large demolishing charges in thin shells for use against fortifications and engineering works, the High Explosives are most efficient. But when employed against armored vessels the effect is very slight unless the projectile penetrates before explosion, or perforates, in which case it attains its maximum effect. Charges as high as 100 pounds of Gun-cotton and Dynamite have been exploded against the face of vertical armor without producing any material damage, and it is not believed that the heaviest projectile yet fired from the Zalinski pneumatic gun will seriously damage a vessel if exploded in contact with the face of the armored sides.

For use against torpedo boats Chalon states that High-Explosive projectiles from rapid-fire guns are very much more effective than gunpowder projectiles from large guns. He shows that projectiles containing 22 pounds of Gelatine dynamite will sink a torpedo boat within a radius of 37 feet of the explosion, and 13 pounds, at 29 feet distance. Hence, the object to be accomplished is to so deaden the explosive that it may remain inactive until the desired moment, when it is exploded by a fuze. This has been effected to such a degree that an initial velocity of 2,000 f. s. is said to have been reached; penetration of 12 inches of wrought iron before explosion has been accomplished; and successful delayed-action fuzes are now in use. The bursting charges employed in such projectiles seldom exceed 30 per cent. of their total weight.

For use in projectiles the requirements of an explosive are essentially the same as for submarine use, excepting that the quality of being unaffected by water is unnecessary, and its effectiveness is not decreased by being quick in its action; but non-sensitiveness to shock is of the most vital importance.

Of the explosives selected for discussion, Ecrasite, Emmensite, Hellofite, Lyddite, and Melinite were not considered under submarine explosives, they being better adapted to other service uses. What their relative values may be for military uses may be judged by a consideration of the results that have been experimentally attained.

Bellite.—An 8-pound charge, exploded under a section of railroad, smashed both rails, splintered sleepers, and made a crater 12 feet in diameter. Three pounds buried 4 feet in the earth made a hole 11 feet wide and 9 feet deep, gunpowder under the same conditions making one 4 feet by 2 feet. Tested comparatively with Dynamite on horizontal three-fourths-inch plates, 2 ounces of each penetrated the plate, the bulge of the Bellite one being 3 inches and of the Dynamite 2½ inches, showing the Bellite to produce a greater rending effect. A fragment, fired as a projectile from a No. 8 small arm failed to explode on impact with an iron plate; but a weight of 59 pounds, when dropped a distance of 5 feet on a small quantity of Bellite, produced a mild explosion, and when the distance was increased to 10 feet a sharp explosion resulted. It has been tested by officers of the Swedish Artillery, and found suitable as an explosive for grenades.

Blasting gelatine.—Shells containing 50 pounds of Blasting gelatine and 5 pounds of Dynamite, fired from Zalinski's pneumatic gun, sank the schooner *Silliman*, by torpedo effect, at a distance of 1,864 yards. Charges composed of 300 pounds of Blasting gelatine and 200 pounds of Dynamite have been fired 1 mile by a similar gun, and according to Abbott's formulæ would have sunk an ironclad within 47 feet and penetrated 50 feet of cement. Zalinski also proposes to clear a channel

100 yards wide and 2 miles long by one hundred and sixty 100-pound charges of Blasting gelatine. These experiments show the feasibility of successfully firing Blasting gelatine from pneumatic guns. In 1864 the English fired charges from a 3-pounder Nordenfeldt R. F. gun, and in 1885 Mr. Nordenfeldt fired it from a 6-pounder with an initial velocity of 2,000 f. s., all the shells exploding by a base fuze against the target; but when the English tried it in a 7-inch gun, in 1885, it burst the gun. Two experiments were made in the United States in 1887, with a 3.2 inch rifle, to fire charges in a shell fitted with an air cylinder and piston rod to diminish the shock of discharge, but on both occasions the gun burst. As a result, it is evident that Blasting gelatine is not suitable to use in large powder guns.

Explosive gelatine.—It has withstood the shock of rifle bullets fired into it at short range. Experiments in Switzerland show it to be more difficult to explode, and more powerful than Dynamite. A 4.72-inch shell required 0.8 pound of Dynamite or 0.4 pound of Explosive gelatine to burst it. In 1883 and 1884 the United States Ordnance Board fired seven 3-inch shells, each containing 6½ ounces of Explosive gelatine, and all but one burst before reaching the target. Deciding that the premature explosions were due to heat generated in the revolving projectile, and not to the shock of discharge, projectiles specially fitted with interior wooden and pasteboard cylinders and copper diaphragms were experimented with in 3 and 8 inch guns, but some premature bursts occurred in each case. Other devices have been patented to discharge this explosive from powder guns with questionable success, one of the most successful experiments having taken place in 1888 by the Turkish Government with a 6-inch Snyder shell containing a 10-pound charge. A 12-inch target was overturned at the first shot, and ten rounds were fired successfully. This explosive is very powerful, and has withstood severe shock tests, but its adaptability to use in powder guns yet remains to be developed.

Dynamite No. 1.—For use against earthworks, Zalinski estimates that his dynamite shell will remove 2,000 pounds of sand for 1 pound Dynamite; Abbot places the figures at 500 pounds of sand. General Gillmore considers that 1 pound of gunpowder will remove 3¼ pounds sand.

The effect of Dynamite on horizontal plates is shown by Zalinski's experiment where 20 pounds exploded on top of fifteen seven-eighths-inch plates, with boiler-plate shield, broke seven plates and shattered the shield; and 70 pounds on fifteen five-eighths-inch plates perforated twelve of them and riddled and blew the plates 30 yards.

Against vertical armor, 8 ounces exploded against the face of a three-fourths-inch plate simply bent it, and 100 pounds produced no material damage when exploded against the face of twelve 1-inch plates bolted together. When explosion takes place by shock of impact of a projectile detonation is so instantaneous that less penetration is accomplished than with an empty shell; but when a fuze is used its position, whether in front of or behind the charge, is of great importance. This is shown by 10-pound charges producing holes in a 1-inch plate of 96 and 192 square inches with the fuze in front and rear respectively; and also by a 4-inch Zalinski shell penetrating seven-eighths inch in the first case and 4.5 inches with the fuze in the rear set to burst one-eighth inch in front of the target.

In 1867 shells loaded with 1.65 pounds of Dynamite were successfully fired in Sweden from an 18-pounder howitzer with 2 pounds powder charge, and from that time up to 1884 numerons firing trials have taken place with varying success. These trials have been confined to guns of small calibre, a 24-pounder howitzer being the largest used, and small bursting charges of from 5½ ounces to 1.65 pounds. When service charges have been successfully used, it can be assumed that the Dynamite was of excellent quality; but in most cases explosions have occurred when the charges have been increased to service conditions. Various methods, such as Snyder's, Justin's, and Graydon's, have been devised by fitting the projectile to relieve the shock of discharge or heat in the bore, but as yet they are imperfect. The most successful is Graydon's method, in which Dynamite is rolled into pellets in paraffined paper, and the shell is lined with asbestos; asbestos wads being also placed between the charge and projectile. Fifty-two 4½-inch shells were fired successfully in 1886 at a range of 2,200 yards, and in 1887 7-inch shells, containing 2.3 pounds each, penetrated a target to depths of 2 and 4 inches, completely wrecking it. Dynamite so prepared, however, will explode from concussion, and special shells are necessary for its use.

Owing to its sensitiveness to shock and heat, Dynamite does not seem suited to withstand the heat generated, or great shock produced, in large powder guns, which latter quality may vary a couple of tons with charges of equal weight according to variations in the condition of the powder.

Ecrasite.—Shells charged with this explosive were successfully fired in May, 1889, and later in the same year an 8.24-inch shell weighing 206.6 pounds, containing 15.88 pounds charge, perforated two plates, each 4 inches thick, and exploded in a third plate. When tested against masonry, ten shots completely destroyed an old fort at Olmütz, not a single casemate remaining intact; and against earthworks, mortar shells charged with Ecrasite are said to be very destructive. It is reported that palisades representing 500 men, when fired at by Ecrasite shells at a distance of 1,300 yards, were all injured.

Emmensite.—When fired into by a pistol ball, only the particles actually struck explode, the detonation not being communicated to the mass. Cartridges 1½ inches in diameter, put up in a tin case and fired as a projectile from a small gun, perforated a 2-inch board without exploding. Seven-ounce cartridges detonated on the *sides*, top, and bottom of five-eighths-inch iron plates, broke them in every case. It has not yet been experimented with in guns of large calibre, but its qualities, as developed in tests of small quantities, show that it is well worthy of exhaustive experiments. The explosive charge of the Sims-Edison torpedo, at present being experimented with abroad, is 500 pounds of Emmensite.

Forcite.—Charges of 11 and 12 pounds of Forcite have been fired successfully from a 6-inch gun in Snyder shells, and all exploded on impact against rock. But it possesses the disadvantage of exploding when struck by musket balls, and by some authorities its stability is still questioned.

Gelatine dynamite.—This explosive is open to the same objection as Forcite; that is, it can be exploded by the impact of a bullet fired from a small arm. In May, 1888, during the experimental firing into a knapsack containing Gelatine dynamite by a commission in Italy, it exploded and wounded several officers.

Gruson's Mixture, or Hellofite.—The shells are fitted to contain the two ingredients, binitro-benzole and nitric acid, in separate glass or porcelain vessels, and are fuzed either in the head or base. In the common shell, the nitric acid receptacle is placed in front and the shock of discharge drives it to the rear and breaks it, complete mixture being accomplished by the revolving of the projectile during flight, and explosion by a time or percussion fuze. The a. p. shell contains the nitric acid in the rear, the breaking and mixing taking place upon shock of impact, and explosion by a delayed action fuze. The interior of the shell is lined with rubber or felt. In 1883, six 5.91-inch shells, each containing 2.4 pounds, were fired at a parapet at 875 yards range, and produced a hole of a capacity of 467 cubic feet, while that made by six similar shells loaded with gunpowder was 13 cubic feet. In 1884 at Palmanova, 5.91-inch shells containing 3¾ pounds gunpowder, 2.6 pounds Gruson's Mixture, and 25½ pounds gunpowder (special 6-calibre torpedo shell) were fired at rest against earth-covered casemates, and Gruson's were found slightly superior to the ordinary shell, but inferior to the torpedo shell. With an increased charge of 4.2 pounds, the Gruson shell excavated a hole of one-third the capacity of that of the 25½ pound gunpowder torpedo shell.

Twelve shells, fired from a 5.91-inch mortar with 2.6 pounds of powder, at a range of 2,958 yards, exploded upon impact, and none prematurely; but their flight was inaccurate on account of the centre of gravity being wrongly placed. Three 9.45-inch shells, each containing 12.2 pounds of Hellofite, were fired from a mortar with a powder charge of 9½ pounds, and their effect was less than similar shells containing 21 pounds wet Gun-cotton. When tested against horizontal armor 11-inch shells, containing 15.8 pounds of Hellofite and 22 pounds of gunpowder, respectively, were used, the Gruson shell showing slightly superior results.

During the experiments no premature explosions are recorded, and the Mixture has proved itself safe to handle and fire; but it requires interior fittings to the shell that considerably reduce its available explosive capacity. Its power is generally considered equal to that of Nitro-glycerine.

Gun-cotton.—Dry Gun-cotton will not resist the shock of discharge of a powder gun under service conditions. Experiments in England from 1864 to 1867 showed that charges of 3 pounds in specially lined shells, when fired with an initial velocity of 1,300 f. s., were exploded prematurely; and although 18 pound charges have been successfully fired from a 24-pounder gun, and 6½-pound charges from a 20-pounder gun, at the Torpedo Station, it simply indicates the perfection reached in its manufacture at that place.

When wet or saturated with paraffin, Gun-cotton is safe for use and is capable of penetrating armor without ignition. When a small percentage of water is used, the detonation produced by impact is of a low order. Wet Gun-cotton can not be ignited by rifle bullets fired into it at short range.

As generally used for explosive charges of shells, wet Gun-cotton is compressed into discs and prismatic or cylindrical grains. When used in the latter form, the charges are of about one-third less weight, and compactness is produced by paraffin, or mixtures of it and canauba wax, poured in at a temperature of 180° F., a hollow space being left in the axis of the shell for the detonating charge. This detonating charge is composed of a fuze and dry Gun-cotton, and must be of sufficient size to produce an explosion of the first order. At Palmanova a 5.91-inch shell, containing a 23½-pound charge, failed to explode with a detonating charge of one-fourth pound dry Gun-cotton and one-eighth pound of Dynamite.

In 1882, trials with 5-calibre mortar shells, containing discs of wet compressed Gun-cotton of 20 per cent. moisture compacted with paraffin, were successful in Germany, and they now use shells of 11-inch calibre, containing 110 pounds wet Gun-cotton. In Italy, mortar shells containing 48 pounds of wet and paraffined Gun-cotton, have been fired, but in both countries guns have burst during experiments. In 1884, Commander Folger fired fifteen rounds from an 80-pounder B. L. R., using service charges, the shells containing 3 pounds of wet Gun-cotton and a one-fourth-inch oakum cushion in the base, and attained a range of 2,000 yards without any premature explosions. In 1885 a very successful series of experiments took place at Walsrode, with Gun-cotton bursting charges in granular form compacted by paraffin, during which over two hundred 3.47-inch shells were fired with an initial velocity of 1,476 f. s.; common 5.91-inch shells were fired from guns and mortars with initial velocities of 1,312 f. s. and 656 f. s., respectively; and 5.91-inch 6-calibre shells were fired from a gun, all without any premature explosions; thus showing the suitability of wet Gun-cotton as a bursting charge for powder gun shells.

As a bursting charge for shells used against troops the English experiments in 1875 with 9-inch shells containing from 10 to 12 pounds of Gun-cotton, showed it to be very good.

Its effect on horizontal armor was shown, in 1884 by Commander Folger, a 25-pound charge blowing a hole of 56 square inches through three 1-inch plates and 7½ inches in the ground.

To determine the destructive effects of wet Gun-cotton shells against earthworks, in 1883 the Germans fired 8.27-inch 5-calibre mortar shells containing 41.8 pounds at a casemate composed of 3.28 feet of brick, 31.5 inches of cement, and 3.28 feet to 4.92 feet of earth, and the shells perforated and burst inside. They also fired 6-calibre 8.27-inch shells with bursting charges of 57.2 pounds, which required 16.4 feet protection to keep them from perforating.

At Palmanova in 1884, a shell containing 24.2 pounds of compressed Gun-cotton was exploded on top of a vault of a thickness of 35.4 inches covered with 7.9 inches of cement and 6.56 feet of earth, and blew a hole 5.6 feet in diameter through it; while a shell containing 25¼ pounds of gunpowder, buried 19.7 inches under the earth, failed to injure it. A similar Gun-cotton shell, exploded 19.7 inches under the earth of a vault 15¾ inches thick and similarly covered, completely destroyed it. Krupp 6-calibre 5.91-inch shells, containing 23 pounds wet Gun-cotton, were successfully fired from mortars, and their penetration being said to be 6.56 feet, the marked superiority of Gun-cotton shells over the gunpowder ones is very evident. Mortar shells of 9.45 inches, with walls only 1.57 inches thick, containing 21 pounds of paraffined discs of wet Gun-cotton, when exploded at rest produced excellent results; but when fired from a mortar, several premature explosions occurred near the muzzle and at distances of 330 and 440 yards, the shell probably being too thin to withstand the pressures. In 1889 the Germans fired wet Gun-cotton shells from 5.91-inch and 8.27-inch guns at a facsimile of a French fort with excellent results.

To determine the effects of Gun-cotton shells against vertical armor, in 1884 Commander Folger fired three unfuzed shells, containing 3 pounds wet Gun-cotton and one-fourth inch of oakum cushion, from an 80-pounder B. L. R., with an impact velocity of 1,250 f. s., against eleven 1-inch laminated plates. All exploded on impact, the target being simply indented 2 inches for an area of 10 inches in diameter, the plates being uninjured. At Ochta a poor shell containing 1¾ pounds' charge, fired against a 10-inch Kolpino compound plate, broke up on impact and exploded with insignificant effect. By treatment, however, Gun-cotton can be sufficiently deadened to pierce armor, and then be exploded by a delayed action fuze. On March 19, 1888, at Rubeland, Germany, using Walsrode wet Gun-cotton treated with acetic acid, and von Forster's delayed action fuze, three shots were fired from an 8.27-inch 22-calibre gun, with Krupp's a. p. shell, 2½ calibres long, containing 2.2-pounds bursting charge, and weighing loaded, 215.6 pounds. The powder charge in the first two rounds was 48.4 pounds, and in the last 30.8 pounds of brown prismatic powder, P. P., C/82. The target was 4.72-inch compound plate on an oak backing 23.6 inches thick, and behind it was an exploding chamber 18.37 feet deep, the rear wall of which was composed of pine logs 9.45 inches thick backed by an earth embankment 11.5 feet thick at the bottom and 3.3 feet at the top. Shot No. 1 pierced everything and exploded in the air. Shot No. 2 perforated plate, backing, wall, and 6.6 feet of earth, and exploded in it making a hole 2.2 feet deep and 8.2 feet in diameter. Shot No. 3 perforated the plate and backing, and lodged in the wall where it exploded.

It is reported that the Russians have successfully perforated 12 inches of wrought iron with a 9-inch Gun-cotton shell which exploded after perforation.

Lyddite.—In July, 1888, the English fired 6-inch shells loaded with gunpowder, Gun-cotton, and Lyddite, against the *Resistance*, which was partially covered with 4½-inch armor, for the purpose of investigating comparative results. But five shots in all were fired, and the results were kept secret. The daily papers state that the Lyddite shell exploded before penetration "owing to the over-sensitiveness of the fuze," but the experiments and those with an 8-inch gun in September, 1888, showed the practicability of ejecting Lyddite shells safely from powder guns. Further experiments against the *Resistance* took place in March, 1889, using 100-pound 6-inch shells with powder charges of 42 pounds, and although secrecy was again observed, it is generally believed that the Lyddite was too sensitive and exploded upon impact with the armor. Those shells which perforated the unarmored parts, however, burst inside the vessel and created "incredible havoc." Most destructive results are said to have been obtained during experiments at Lydd against armor targets, and it is now stated that the English have succeeded in piercing 5 inches of armor with Lyddite shells before explosion.

In Italy an unfuzed shell, loaded with a substance said to be Lyddite, exploded upon impact with a plate 0.63 inch thick, tearing a hole 4 by 5 feet; but another shell, fuzed, perforated a 1.65-inch plate and exploded behind it, showing its uncertain action, but destructive effects against unprotected parts.

Melinite.—That melinite shells can be safely fired from powder guns has been repeatedly shown by practical experiments in France. Initial velocities of 2,000 f. s. are said to have been obtained with 6.3-inch guns, and 1,300 f. s. and 985 f. s. with 8.66-inch mortar shells containing 70 and 121 pounds respectively. Shells weighing 121 pounds containing 23 pounds of Melinite have been fired from 6-inch guns, and during the experiments at Chalons against fortifications, mortar shells containing 197 pounds were fired.

Of the five premature explosions that have occurred with Melinite, the one previous to January, 1887, was attributed to the thinness of the walls of the shell; that of a shell in store at Belfort, in March, 1887, to the use of potash in cleaning out the shell, it causing chemical instability; at Bourges, April, 1887, the explosion of a shell was supposed to have been caused while inserting the fuze; and the second explosion at Bourges, October, 1890, to the carelessness of a workman while loading a shell. In June, 1887, during firing trials against the *Belliqueusc*, the 5.6-inch gun burst at the second round, using shells weighing 66 pounds and containing 28 pounds of Melinite. Berthelot ascribes this accident to the grease, used on the screw thread of the fuze, getting inside the shell and setting up instability.

The vertical fire effect of melinite shells against cement-covered casemates was shown to be slight, 4.1 feet thickness being sufficient protection against 8.66-inch mortar shells, containing 121 pounds, fired with an initial velocity of 984 f. s., which produced craters 3.28 feet deep and 4.9 feet wide, the gases taking the line of least resistance. But when the explosion occurred at the foundations it was found necessary to increase their thickness 13.1 feet. In experiments against cement and armor-faced cupolas, 10 feet of cement proved better protection than 6 and 8 inches of armor, which, however, showed unexpected resistance and was not perforated. Disastrous results to the personnel of fortifications are also to be expected from the carbonic oxide produced; while digging for melinite shells, which had been fired several days previously, several French soldiers were overcome by the gases.

In addition to the above-mentioned cupola experiments, melinite-charged shells have been further tried against vertical armor. In 1887 the *Belliqueuse*, fitted with armor of from 4¾ to 5⅞ inches thickness, was fired at by shells of 5.51 and 6.3 inches calibres, weighing 66 and 99 pounds, and containing 6.2 and 8.8 pounds bursting charges. The results were kept secret, but, in consequence of the experiments, the French marine decided to protect their ships with complete side armor of from 4 to 5 inches thickness. The shells which exploded in the unprotected parts blew holes 5 feet square, and those exploded within the vessel proved very destructive, scattering fragments in all directions, and killing the sheep representing the crew by them and the poisonous gases. During another set of experiments, in June, 1890, six melinite shells are said to have perforated both sides of the *Provence* without exploding, that is, 9.4 inches of armor in all, she having been fitted with 4.7-inch armor.

Several authorities, English and German, doubt the safety of Melinite, and assert that it deteriorates and decomposes when kept in the tropics; but the French seem to consider it safe to handle and store, and have added to its safety by filling two-thirds of the shell with Cresilite and ramming Melinite into the other one-third.

At the explosions at Belfort and Bourges it proved its non-sensitiveness to explosion by influence, in both cases loaded shells in the near vicinity failing to explode.

Nitro-glycerine.—This explosive, used alone, is too sensitive to shock for use in powder guns; and, being in liquid form, is unsuited to service uses. Its power and capability of use in pneumatic guns, however, is shown by the results of an experiment conducted by the German Admiralty in 1889, when two 11.7-inch shells, each containing 66 pounds of Nitro-glycerine, destroyed a vessel at a distance of 2,080 yards.

Attempts have been made to deaden its sensitiveness to shock, Smolianinoff's mixture *Americanite*, consisting of from 80 per cent. to 97 per cent. of Nitro-glycerine mixed with a secret liquid, the function of which is to render it less sensitive to shock, being among the best; but although twenty rounds of from 1 pound to 1½ pounds of this mixture were successfully fired from a 24-pounder in October, 1887, and three rounds from a 100-pounder Parrott in November, 1887, without premature explosion, all in the latter case exploded on impact. In June, 1888, three shells were fired from an 8-inch M. L. R., but as the third exploded on impact with the water, the explosive as yet developed seems too uncertain for military uses. A special burster is employed with this explosive, and its keeping qualities, as shown by a 2½ years' storage test, proved excellent.

Roburite.—Experiments at Chatham, June, 1887, showed this explosive to possess greater dispersing effects than Gun-cotton and as great a power as any of the picric powders. Its great safety in handling and convenient granular form, combined with its strength, seem to make it worthy of other experiments to develop its serviceability.

Tonite has successfully withstood severe tests for sensitiveness, resisting detonation by impact of rifle bullets; but no data is at hand of actual firing tests with this explosive.

Assuming gunpowder as a standard at 1, the explosive effects of the various explosives, as given by different authorities, are:

Blasting gelatine	16	Tonite	9.5
Forcite	15	Carbo-dynamite	6.5
Ecrasite	15	Bellite	6
Explosive gelatine	13	Gun-cotton	5.5
Hellofite	13	Melinite	3
Nitro-glycerine	13	Lyddite	3(?)
Dynamite	11	Roburite	3
Emmonsite	*10–4.5	Gunpowder	1

* Varying according to grade.

From the results of the experiments cited above, we can divide the explosives under three heads, viz:

A.—Explosion caused by impact of small-arm projectiles.	B.—Premature explosions during experiments in powder guns.	C.—No premature explosions by bullets or during firing trials.
Blasting gelatine. Dynamite, No. 1. Forcite. Gelatine dynamite. Nitro-glycerine.	Blasting gelatine. Explosive gelatine. Dynamite, No. 1. Gun-cotton, wet (none since 1882). Melinite (only one explosion). Nitro-glycerine.	Bellite. Ecrasite. Emmensite. Hellofite. Lyddite. Roburite. Tonite (no firing trials).

The defect of those included in column A is a very important one, and unfits them for general military use. Of those in column B, wet Gun-cotton has shown no unsafe qualities since 1882, and is now considered as the safest known explosive, entitling it to be included in column C. Melinite has only had two premature explosions during firing trials, and is fully trusted by the French as now prepared. The great explosive effect of the others in column B, however, make them very desirable for large demolishing charges when fired with low initial velocities and penetration before explosion is not required; and from its non-sensitiveness to explosion through impact of projectiles, Explosive gelatine seems to be the one best fitted for use in pneumatic and other guns where the propelling force of moderate strength, not subject to great variations, is gradually applied.

Those included in column C have been shown to possess the requirements of stability, safety, non-sensitiveness to shock, and shattering effects, suitable to military uses from powder guns; but of them, Hellofite is placed at the disadvantage of requiring special shells, the interior fittings of which reduce materially the charge capacity, and hence the destructive effect; and Tonite has not been sufficiently experimented with to prove its adaptability under various conditions.

Summing up, we find Explosive gelatine eminently suitable for use in pneumatic guns; and as bursting charges for projectiles from powder guns—

Name.	Type.
Bellite	Sprengel.
Ecrasite	Gelatine.
Emmensite	Picric Powder.
Gun-cotton (wet)	Nitric Ester.
Lyddite	Picric Powder.
Melinite	Do.
Roburite	Sprengel.

showing that, with the exception of Ecrasite and Gun-cotton (wet), the Picric Powders and Sprengel Explosives seem to be the two types supplying explosives best adapted to general military use.

Of the various high explosives, the following have been adopted in different countries:

Austria: Ecrasite has been adopted for the Army.

England: Gun-cotton (wet) is adopted for use in submarine mines, and Lyddite is being experimented with for use in shells.

France: Gun-cotton (wet) is used for submarine mines, and Melinite for shells.

Germany: Uses wet Gun-cotton shells.

Italy: Has adopted wet Gun-cotton for use in submarine mines, and is experimenting with it and Lyddite as bursting charges for shells.

Russia: Shells and submarine mines are loaded with wet Gun-cotton.

Sweden: Has adopted Bellite as an explosive for military and submarine purposes.

United States: Wet Gun-cotton has been adopted for the Navy for submarine use; the Army have used Dynamite, but are inclined to adopt Blasting gelatine or Forcite. The naval authorities are building a short rifled gun to experiment with shells charged with Emmensite.

In concluding this article we would state that no matter how safe an explosive may appear or have proved itself to be—and of them all Gun-cotton seems to lead in this quality—no better advice can be given to those persons dealing with them than that of Major Cundill, to always "Treat an explosive as an explosive," and observe all precautions and directions regarding its use.

IX.

THE TORPEDO VESSEL—A HISTORY OF ITS DEVELOPMENT.

By Lieut. RIDGELY HUNT, U. S. Navy.

A great development has taken place in recent years in that class of war ship known as the torpedo vessel, a class constructed by the different navies, in which are sought the characteristics of small size of hull, light gun armament, powerful torpedo offense, highest speed, thoroughly good sea-keeping qualities, and relatively large coal capacity.

Experience has sufficiently demonstrated that high-sea torpedo boats, though able to go to sea, are not properly sea-keeping. Life on board such small craft is unendurable in even moderately rough weather; for though the boat may escape injury, the personnel will be demoralized by the discomfort incident to cramped accommodations and incessant motion.

As a dividing line between the torpedo boat and the torpedo vessel a displacement of 300 tons has been generally accepted. And in order to distinguish the torpedo vessel from the torpedo cruiser an upper limit of 1,000 tons displacement seems to have been adopted. These restrictions are not absolute and future developments may abrogate them.

The credit for bringing the torpedo vessel to the attention of the world belongs to the Germans. In 1876 they purchased from the Thames Iron Works Company, of London, the *Zieten*, of 975 tons, a long, low vessel, resembling a schooner-rigged steam-yacht. The torpedo tubes for ejecting locomotive torpedoes were situated one in the bow and one in the stern, 6 feet under water, and never worked satisfactorily. On her trial the *Zieten* made a speed of 16 knots; a remarkable performance for a vessel of her size and time.

During the same year the Italians endeavoring to construct a vessel of the new type, launched the *Pietro Micca*, of 608 tons, fitted with two under-water tubes. A speed of 18 knots was anticipated; unfortunately but 14 knots were made, and the vessel is now scarcely recognized as belonging to the type.

The year 1877 found Germany in the field with the nondescript torpedo vessel *Ulan*, of 377 tons, fitted to use spar torpedoes. In all respects she was a disappointment; her speed was only 12.2 knots.

Sweden put forward the *Ran*—since called the *Drott*—of 630 tons, with one under-water bow tube, and the low speed of 12.7 knots.

The next step was taken by Austria in 1879, with the *Zara* and *Spalato*, of 840 tons each. In their fittings they marked a decided advance in the construction of torpedo vessels having protective decks, high-speed compound engines, locomotive boilers, and two above-water torpedo tubes; in speed they failed, barely reaching 13 knots.

While these efforts were making to provide rapid and efficient vessels to carry the torpedo on the high seas as their principal means of offense, the torpedo boat was moving forward in the same direction, accomplishing better results and winning greater confidence, and it looked as though the boat would displace the vessel. Again Austria in 1882 and 1883 endeavored to lead with two new vessels similar to the *Zara*, except of increased length; but only 14 knots could be reached.

Germany likewise seemed determined upon providing means to capture and destroy these small craft which at this time were making the extraordinary speed of 21 knots, so she put afloat in 1882 the *Blitz* and *Pfeil*, of 1,380 tons each. Their length was 245 feet; breadth, 32 feet 6 inches; and draught 13 feet 6 inches. The armament consisted of one under water-tube in the bow, one 4.9-inch B. L. on top of a short forecastle, and four 3.4-inch B. L. in broadside. The *Blitz's* machinery consisted of two sets of compound engines and eight locomotive boilers fitted to work with forced draft and operating twin screws. The vessel made a maximum speed of 18 knots and immediately attracted attention. On account of her size, however, she should be classed as a torpedo cruiser, a new type, of which she was the forerunner, that absorbed attention for the next few years to the exclusion of the torpedo vessel.

France was soon to the front in this new development, launching in 1885 the *Condor*, of 1,240 tons. This *croiseur torpilleur* was of the newest style of construction, having protective deck, splinter deck, double bottom, and cellulose water-line belt. The machinery consisted of two sets of compound engines and four locomotive boilers fitted for forced draft. The armament, besides the five 4-inch B. L. guns, contained five above-water tubes. On trial the *Condor* made 17.8 knots.

Austria and England followed suit, the former with the *Panther* and *Leopard*—built in England—of 1,530 tons and nearly 19 knots speed, and the latter with the *Scout*, class of 1,600 tons and 17.6 knots; and later with the *Archer* class, of 1,770 tons and 17.5 to 18 knots.

The desirability of having with all fighting sea fleets some fast handy vessels, capable of discharging torpedoes was thus recognized, but the necessity for such vessels additionally designed to operate against torpedo boats, which, in their increasing numbers and better sea-going qualities, had become a serious menace to the safety and morale of a fleet, was now regarded as imperative. The French *Condor* promised a partial solution of the problem, but in copying her and improving on her, the torpedo vessel became the torpedo cruiser, with all the capabilities pertaining to the cruiser class, capabilities most desirable, but which seriously interfered with the handiness, manœuvring powers, and maximum speed so indespensable in torpedo-boat warfare. Cruisers of 1,300 tons and upwards could not be easily handled or obscured among a number of ships in close proximity to one another, nor would they be difficult objects to hit, and every shot would tell.

The first to grasp the situation were the French. While laying down the *Condor*, they began also the construction of a new type called by them *avisos torpilleurs*, eight of which were launched between 1886 and 1888. These eight torpedo vessels are known as the *Bombe* class, the *Bombe* being the first one afloat.

In order that a torpedo vessel should properly fulfill her rôle it is necessary that she should be as small as possible, so as to escape in a certain measure being struck by the fire of hostile cruisers and armor-clads; at the same time she should be large enough to go to sea and to mount an efficient battery of rapid-fire and machine guns to penetrate easily the hulls of attacking torpedo boats. It is equally important that she should have the speed of her enemy, in order to pursue with the certainty of overhauling; light draught of water is a desideratum; it permits chasing in shallow waters. Light draught also conduces to the safety of the vessel, because torpedoes launched against her have thus the chance of passing beneath the bottom without making contact.

In designing the *Bombe* class, therefore, the chief points aimed at were high speed, flotability, great manœuvreing powers, and small size. Accordingly, each vessel is 395 tons displacement, 182 feet long, 21 feet 6 inches beam, 10 feet 6 inches draught, and is fitted with two three-bladed screws worked by two sets of high speed three cylinder compound engines to which steam is furnished by four locomotive boilers. The *Bombe*, on her steam trials, is reported to have developed more than 1,800 H. P., and to have realized a higher rate of speed than 19 knots.

Other desirable qualities in a torpedo vessel, such as efficient protection to the vitals, habitability, so that long cruises can be made without injury to the health of the crew, a secure platform for a battery possessing high ballistic properties, and finally a coal capacity and an endurance sufficient for moderate cruising were all sought after in the construction of the *Bombe* class.

To secure these many elements of success the French built these pioneers of the modern torpedo vessel of light steel with two steel decks, the upper one turtle backed, so in outward appearance the type resembles a torpedo boat. The water line is protected by a belt of cellulose, above which and surrounding the machinery are placed the coal bunkers of a capacity of 46 tons of coal so disposed as to protect the vitals. It is estimated that this amount of fuel will give an endurance of 3 days at 18 knots speed and of nearly a month at from 5 to 10 knots.

The interior of the vessel is divided into nine water-tight compartments, in the forward one of which are carried the torpedo machinery, the torpedoes, and the two above water bow tubes. As additional means of offense each vessel mounts four 47 millimetre R. F. G., one forward, one aft, and one in each broadside in half turrets, and three 37 millimetre machine guns. There is also a powerful search-light on a bridge placed just abaft the conning tower. The complement consists of three officers and sixty men. Further particulars of this type are given on page 139 of No. V.

The *Bombe* and her consorts have proved to be too light for the work demanded of them; service on board is as arduous and wearying as that in torpedo boats. Also great trouble has been experienced in using the locomotive boilers. It has been decided to remove them and substitute those of d'Allest of a multitubular pattern.

After the stimulus given to the naval world by the advent of the *Bombe*, France withdrew from the contest, remaining inactive until 1889, when she laid down the *Léger* and *Lévrier* of 450 tons each, and made preparations for beginning three others like them. At the same time she began two more *Condors*. In 1890 the successful work of the Italian constructors attracted her attention, and preparations were made for laying down two torpedo vessels of about 750 tons displacement.

Ever since the French laid down the *Bombe* class in 1883, the development of the torpedo vessel has been one of the most prominent features of modern naval architecture, a development due to improvements in the system of construction of the hull, improvements in the forms of the vessels, and finally to improvements in the engines and boilers.

Since it is a necessity to preserve the minimum size consistent with good sea-going qualities while attaining at the same time the highest possible speed, the weight of the machinery must take up a large proportion of the displacement; this machinery must be of the high speed type, run by the best steam generating boilers worked with an intense draft produced by fans, for only by such means can enormous power be developed upon light weights of machinery.

This is exemplified in the *Destructor* built in 1886 by Thomson of England for the Spanish Government. On a displacement of 350 tons she carries machinery weighing 153 tons. The *Destructor* is fitted with two sets of triple expansion engines—the first fitted in a torpedo vessel—and four locomotive boilers. On trial she developed 3,830 horse-power and a speed of 22.6 knots. A complete description of the vessel and her performances is given on page 272, No. VI. Spain did not follow up this type with any subsequent vessel until 1889, when she launched two of 570 tons displacement each, descriptions of which are given on page 43, No. IX. The estimated speed is 19 knots.

So widespread was the influence exerted by the *Bombe* that the year

1886 found all the principal maritime powers striving to produce a perfect torpedo vessel. The functions that should be especially intrusted to this increasing type of modern vessel were clearly defined at this time to be as follows: In an action between two fleets their task would be to destroy the enemy's torpedo boats before the latter could get within range of the armor-clads. During a blockade they would cruise inside the blockading fleet for the same purpose, and to give warning of all movements of the enemy. When cruising with the fleet, they would act as scouts in conjunction with larger vessels, and be a means of communication with detached squadrons or single ships. They would be expected to engage vessels of their own or similar types; to support the movements of torpedo boat flotillas, and to perform acts of daring such as attacking a squadron under way at night, or forcing a blockade. Finally, they would be required to undertake all the duties that are supposed to devolve upon high-sea torpedo boats.

England, in her desire to secure that vessel best suited to the performance of the above multifarious duties, launched in 1886 the *Rattlesnake* of 550 tons, and followed her the next year with the *Grasshopper* and two others of 525 tons. The new type, known to the admiralty as the "torpedo gunboat," is built of steel with half poop, forecastle, conning tower, and bridge, stands well out of water, and has good accommodations between decks. In addition to one torpedo tube in the bow, another in the stern and one in each broadside, training through 90 degrees, the *Rattlesnake* class mounts one 4-inch R. F. G. on the forecastle behind a steel shield, and six 3-pounder Hotchkiss R. F. G. Above the bridge an electric search-light is fitted. The motive power consists of two sets of vertical triple expansion engines actuating twin screws, and steam is supplied by four locomotive boilers, placed in two separate compartments. The weight of the engines and boilers is 110 tons. The coal capacity is 80 tons, stored so as to afford a protection of 3 feet thickness to the machinery. This amount of coal should give a steaming radius of 2,400 miles at 10 knots, or 570 miles at 18.5 knots. On trial the *Rattlesnake* developed 2,860 I. H. P., 322 revolutions, and a speed of 19.5 knots.

In the report of the committee on naval manœuvres, 1888, the above vessels were found to be satisfactory sea boats and safe vessels provided they were carefully handled. They behaved at sea much the same as a large torpedo boat, their light draught making it difficult to steer a steady course when there was anything approaching a heavy sea. The gun platform was found to be an unsteady one except in nearly calm weather.

After the termination of the manœuvres of 1889, the vessels were reported as being remarkable for efficiency and handiness. Nevertheless, it is said that officers called upon to command them are unanimous in condemning their flimsy manner of construction. The sides are so thin that a blow from the sea is sufficient to distort the plates and interfere with the training arrangements of the topedo tubes.

Hoping to obviate these defects England put forward in 1888 the *Sharpshooter* class, of 735 tons displacement, with machinery weighing 170 tons. These improved *Rattlesnakes* have shown weaknesses in both hull and machinery; the former has been strengthened as much as possible, and the original demand of 4,500 horse-power for the machinery has been reduced to 3,500. Seven of the class have made trial speeds of over 19 knots; eight others which have been laid down and ten more which are about to be commenced will all be given an increased displacement, probably 850 tons, so that the hulls can be made strong enough to stand the high speed engines and so that additional weight can be given the machinery. Complete descriptions of these torpedo vessels are given on page 303 of No. VII and page 336 of No. VIII. Accounts of their steam and speed trials are to be found on page 22, No. IX; also in the notes on ships of the present volume.

Italy began developing the torpedo vessel alongside of England, though in somewhat different lines, her first vessel being the *Tripoli* of 860 tons, in which were introduced several novel features of construction and mode of propulsion. The protective deck covering the vitals is 1.5 inches thick, of steel, and the 150 tons of coal are so disposed as to afford additional protection. The machinery, weighing 155 tons, consists of three sets of compound engines actuating three screws—an entirely new principle in 1886—and six locomotive boilers. It is said that she made a distance of 50 miles at an average speed of 20 knots, the maximum speed being 24 knots.

The armament consists of four 57-millimetre R. F. G. and two 3-pounder R. F. G., and there are five above-water tubes and one search light.

This vessel met with considerable favor, and three others like her were launched during 1887 and 1888. The defects in them all were due to lightness of construction, the hulls vibrating so that it was found impracticable to force them beyond a speed of 18 knots.

During the building of the *Tripoli* the Italians were also at work on a smaller vessel, the *Folgore*, of 317 tons, quite after the pattern of the *Bombe*. She made a speed of nearly 23 knots, but vibrated so excessively as to seriously interfere with the working of the torpedo apparatus and the battery. A sister vessel soon followed, after which the class was abandoned.

The policy is to construct larger vessels, better armed and better able to keep the sea, following generally the style of the *Tripoli*. Except in the *Monzambano* and the *Montebello*, launched 1888, the three screws have been abandoned in favor of the twin screws. Among the newest of the Italian torpedo vessels and one of the most successful of the class in the world is the *Partenope*, completed in 1890. Her dimensions are: Length, 229 feet 7 inches; breadth, 27 feet; depth, 17 feet 9 inches; draught, aft, 11 feet 6 inches; displacement, 859 tons. Her hull is of steel built on the cellular system, with a complete steel deck 1.6 inches thick;

she has a ram bow, two smoke pipes, and is schooner rigged; the crew comprises seven officers and one hundred men. The motive power consists of two sets of vertical triple expansion engines actuating two three-bladed propellers; steam is furnished by four locomotive boilers; the weight of the machinery is 160 tons. On trial the *Partenope* worked up to nearly 4,300 H. P., developing a speed of 20 knots. The amount of coal carried is 180 tons so disposed as to give four feet of protection to the machinery. The armament is one 4.7-inch R. F. G. on forecastle, six 57 millimetre in broadside, two 37 millimetre machine guns, and six torpedo tubes, one ahead, one astern, and two in each broadside, and she carries two powerful search lights. Italy has five more similar vessels in hand, and as far as can be learned she leads the world in the production of a nearly perfect torpedo vessel.

While England and Italy were working in the direction above indicated, Germany was laying down larger vessels of the torpedo cruiser type until 1890, when she launched the *Meteor* of 950 tons, described on page 42, No. IX, considered a failure because of excessive lightness of build. Four others of a less displacement, 780 tons, are now in hand.

Germany, however, has recently developed a new and very successful type, officially designated "torpedo-division boats." They are intended to serve the purpose of guiding a fleet or division of sea-going torpedo boats, and are required to take on board stores and spare articles for a whole division. They are fitted with complete workshops to make any necessary repairs at sea, and, in addition, are armed with eight R. F. G. and two tubes forward. The engines are triple expansion, and the boilers, two in number, of the locomotive type are fitted with Schichau's patent firing and ventilating arrangements. The dimensions vary according to the displacement, which ranges from from 300 tons to 450 tons; generally the length is between 180 and 200 feet; beam about 23 feet, and draught 10 feet. A maximum speed of 21 knots has been made by some of them; others are credited with 23 knots, and the ones building, those of 450 tons, are expected to make 26 knots. It is proposed to have ten of these boats; seven have already been tried.

Russia made a good beginning in 1886 and 1887 towards successfully developing the torpedo vessel by launching the *Ilgin* and *Saken*, 600 tons, with complete protective deck and 100 tons of coal protection. Two sets of triple expansion engines, six locomotive boilers, and twin screws gave a speed of 20 knots. These vessels carry six above-water tubes and ten 47-millimetre R. F. G. In 1890 Russia bought the *Kazarski* a 400-ton vessel built by Schichau. She has done her 21 knots. This purchase from Schichau was due to the great success attending the performances of the Austrian torpedo vessels built by him, of which the first launched in 1887 was the *Meteor* of 350 tons, of a type analogous to the French *Bombe*, but faster and better armed, making 23 knots and mounting ten 47-millimetre and one fixed above water bow tube. So satisfactory was the *Meteor* that two more were ordered, the *Blitz* and *Komet* of 360 tons, speed 21.3 knots, This class was then abandoned for one of a larger tonnage of displacement, and in 1889 and '90 the *Planet*, of 480 tons (page 358, No. VIII, page 46, No. IX), and the *Trabant*, of 540 tons (page 43, No. IX), were purchased. Both vessels have a fixed bow tube above water and a pair of training tubes aft on deck.

The advancement of the torpedo vessel, as deduced from the history of its development by the several powers of Europe, is evidently towards increased size; first, with the object of securing the strength of hull necessary to stand the strain imposed by high-speed engines, and second, to provide seaworthiness, both as regards the vessel herself and as regards her crew. While some recent constructions have proved faulty in these respects, yet the successes have been many, especially in the case of the Italian vessels and in those most recently tried in England, built to the order of the Government of Chile. The *Almirante Condell* and *Almirante Lynch* are indeed remarkable vessels, if accounts of them do not exaggerate their qualities. They were built by Messrs. Laird Brothers, and closely resemble the *Sharpshooter* class, but are slightly larger, better protected, and are superior sea-keeping vessels. They are flush deck, with a high forecastle and half poop, that can be made water-tight. There is no external keel, but internally there is a deep keel plate, reinforced by a longitudinal bulkhead. To diminish rolling two deep bilge keels are fitted. To reduce weight and to insure strength the system of overlapping butts for the skin plating is adopted. The sides amidships tumble home, and at load draft have a free board about 5 feet. In the run the deadwood is cut away to allow room for the balanced rudder. The ram stem is strengthened by stringers to enable it to be used as a weapon of offense. There is a conning tower forward of 1-inch steel, and aft, at the break of the poop on the main deck, is a steel hood, inclosing steering gear, speaking tubes, torpedo-firing apparatus, etc., similar to that fitted in the conning tower. The upper deck is steel, with teak sheathing. All hatch openings are protected against plunging fire by steel armor plates, and as further protection to vitals against the fire of light guns there is an inch-thick strake of plating extending fully two-thirds of the length of the vessel. There are in all forty-five water-tight compartments. The pumping power is 600 tons per hour.

There are four locomotive boilers each with two furnaces; the working pressure is 155 pounds per square inch. Each boiler is so arranged that it can be cut off from the rest.

The engines are triple compound. The propellers are of manganese bronze, three-bladed, cast solid; the crank and propeller shafting is of steel and is hollow.

The vessels are lighted throughout by electricity and carry a 25,000-candle power projector on the conning tower.

The armament of each vessel consists of five above-water powder impulse tubes, Canet system, mounted on the main deck, one in the bow and two on each side; three 14-pounder Hotchkiss R. F. G., two on the forecastle in echelon and one on the poop; four 3-pounder Hotchkiss R. F. G., one each side in sponsons amidships and two on the poop; and several machine guns.

On their highly satisfactory steam trials the *Lynch* made 21.2 knots and the *Condell* 20.3 knots.

Messrs. Laird Brothers have also produced two other good vessels for the Argentine Republic, the *Espora* and *Rosales*, of 520 tons each, built on the same general principles as the above and tried in 1890, each making a speed of 19.8 knots.

It is to be remembered that in the torpedo vessel the primary arm of offense in an engagement with heavier vessels is the torpedo, a weapon of greatest possibilities but as yet of uncertain value. With a thoroughly well-trained crew a torpedo should prove a most deadly missile, but not otherwise. As an instrument of precision it has thus far in its development been defective and under unfavorable conditions has been often erratic. Its greatest advantage, therefore, lies perhaps in the moral effect it produces, which is demoralizing to a degree. In these torpedo vessels the idea is to possess the power under favorable circumstances of delivering a deadly blow against a larger antagonist, while at the same time they protect themselves against torpedo boats by the use of a concentrated hail of shot delivered at a range beyond that of any smaller foe.

In comparing the torpedo vessel with the cruiser it should be observed that the former are nothing like as expensive, a *Scout*, 1,600 tons, costing for hull, machinery, and gun mountings $437,580, a *Sharpshooter*, 735 tons, but $250,125. The latter carries an armament which will be effective against any ships the *Scout* is likely successfully to encounter. In speed the two stand as 17 to 19 in favor of the torpedo vessel. In complement as 130 to 85 in favor of the *Sharpshooter*. In no respect are the vessels inferior as cruisers, their steaming radius, if not so great, is amply sufficient and the cost of maintenance is vastly less.

In comparing the torpedo vessel with the gun boat the superiority of the former becomes still more apparent. Compare the *Thrush*, 800 tons, with the *Sharpshooter*, the former cost $200,000 for hull and machinery alone, the latter, including gun mountings, $250,125; the former's speed is 13 knots, the latter's, 19. The complements are eighty-five in both, and in both the coal capacity and steaming radius are alike. The battery of the *Thrush* is six 4-inch B. L. R., and two 3-pounders; that of the *Sharpshooter*, two 4.7 R. F. G., and four 3-pounder. The former has no torpedo armament; the latter has three tubes and her sister vessels building will have four and five tubes.

To institute a comparison between a torpedo vessel and a torpedo boat it is only necessary to say that the former can cruise, the latter can not.

Except in the one item of cost the vessel is the superior of the boat, performing better all the functions of the boat. If it be conceded that one vessel can perform the work of two boats, then the advantage of cost in favor of the boat disappears.

In looking at the building projects of the maritime nations all the world over, the conclusion seems inevitable that in the future the torpedo vessel is destined to reach a place of first importance in development, numbers, and usefulness.

X.

THE SYSTEMS OF PROMOTION IN SEVERAL EUROPEAN NAVIES

By Lieut. A. F. Fechteler, U. S. Navy.

This article is a continuation of the article by Lieutenant Mentz in No. IX, entitled "The Ministries of Marine and Personnel of several European Navies."

It will, however, deal only with the personnel, and exclusively with officers of the executive branch, that being the burning question of the day, especially in the English and French navies.

In the article of No. IX, the general systems of promotion of several European navies were described, and the present article will give further particulars of those systems and of the resulting effect on the personnel.

Foreign official publications have been the main sources of information.

ENGLAND.

Midshipmen and sublieutenants may be considered on probation. Their promotion, or whether they remain in the service at all, depends on the character of the examinations they pass.

Lieutenants and officers of higher grades undergo no examinations.

Lieutenants are promoted to commanders and commanders to captains exclusively by selection; subsequent promotions are strictly by seniority.

The selection of the lieutenants and commanders to be promoted rests for the most part in the hands of the First Lord of the Admiralty, who is assisted in this matter by his Naval Secretary, an officer on the active list, at present a captain.

Under the Internal Regulations of the Admiralty the First Lord has under his charge the promotion of all naval officers. For the selection of the lieutenants and sublieutenants, however, he leaves the preparation of the list to the Second Naval Lord, who has their records and appointments under his charge.

Promotions are made twice a year, June 30 and December 31.

The Naval Secretary of the First Lord produces the list before the Board, composed of the First Lord and the Naval Lords, and the promotions are made from this list. The records of the officers, recommendations, etc., kept by their Lordships according to the Internal Regulations, are presented and discussed in each case, which is disposed of accordingly. As the majority of promotions are made from those on sea service, an effort is made to give the promotions in each squadron in proportion to the personnel of that squadron.

The following is an extract from a speech in the House of Lords, March 16, 1891, by Lord Sudely, an ex-naval officer. Opinions differ as to his proposed remedies, but his description of the condition of the personnel is accurate and uncontradicted:

> I am anxious to call your Lordships' attention to the block of promotions which exists at present in the list of lieutenants in the Royal Navy, and I wish to ask Her Majesty's Government what steps they are taking to remove it, and especially what steps they propose to take to prevent it arising again.

Speaking of the present retirement scheme, originated by Mr. Childers, he says:

> It was an enormous boon to the Service, and, if occasionally some slight alterations have been found to be necessary, it is only certain small points which it has been found desirable should be carefully examined and altered, so that any friction that may arise may be put right and the whole scheme be enabled to work properly. * * * It must be remembered that the lieutenants' list is the backbone of the executive service of the Navy. It is from that branch that you must expect all your small craft to be commanded in time of war; and when you remember the enormous number of torpedo vessels and other small craft which you will want in time of war, you will see at a glance how necessary it is to have a very large body of efficient lieutenants. * * *
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> It is from this branch that all your commanders, all your captains, and all your admirals in the future must be picked. * * *
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> Unfortunately, in the senior ranks there is a great amount of discontent, and I am afraid I must admit it is a discontent and dissatisfaction which you could do nothing else than expect. Before I go into the question to show your Lordships how very old these lists have become, I should like to point out that in the opinion of the most competent judges it is well known that the lieutenant of 10 years' seniority has arrived at that point when he ought soon to be promoted. * * *
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> Now, I should like to point out how very much older the list is becoming, taking it for granted, as I have attempted to show, that a lieutenant of 10 years is as old as he ought to be before being promoted. In 1871, 2 years after the retirement scheme was introduced, I find there were 79 lieutenants of over 10 years' seniority; in the year 1880 those numbers had gone up to 171; in 1885 they had gone up to 262; and in 1891, at the present time, they have gone up to 316. You have got over one-third of your lieutenants' list, composed of men who, in the opinion of all the most competent judges, are far too old and ought to be retired. Now, how is this to be done? How this is to be remedied is of course a very difficult matter. The average number of promotions from lieutenant to commander is only 23, and this number you can not possibly increase. It can be proved to demonstration that now only 2 lieutenants out of every 7 can possibly become commanders, and I apprehend there can be no doubt when you once get your list up to 1,000 that it will be only 2 out of 15 who will ever become commanders. This is most unsatisfactory to the officers and I apprehend it is most detrimental to the navy. * * *
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> If you take the period of 5 years from 1886 to 1890, you will find that 136 lieutenants have been promoted; of those only 15 were under the age of 34. Now taking

the commanders' list at 6½ years and taking the captains' list at 15 years, a lieutenant of 34 must wait until he is 53 before he can be at the top of the captains' list. It is therefore perfectly clear that hardly any of these officers can ever become admirals.* Not only have you this great objection, but you have from the economical point of view a terrible state of things existing, because what you are really doing is that you are greatly increasing the cost of retirement; you are promoting officers who must have retired before they can become admirals, and in that way you do very great harm to that charter of retirement which Mr. Childers brought forward. If you take the last batch for promotion you will find there were 7 commanders and 11 lieutenants promoted, and then only one can ever hope to obtain flag rank. The youngest lieutenant promoted was 34 years and a half old, the youngest commander was 39, and practically only one was ever likely to attain flag rank. * * * Well then what is to be done? You have over 330 senior lieutenants, men who have in their youth looked forward as midshipmen to the day when they might become admirals, but from no fault of their own, imbued as they are with the utmost zealousness, they find they cannot get promotion, but must linger on until they become 42, and then they are retired. You can not say, "If we can not promote them we will retire them," because unfortunately, owing to that mistake in reducing the number of cadets, you have not got a sufficient number of sublieutenants to fill their places. You dare not reduce your lieutenants' list below what it is; it is already too low, and therefore, do what you will, these unfortunate men must remain where they are. If that is the case, I think there is only one answer; that, if you find from no fault of their own these men must remain in a position for which they are unfitted, I think the only thing you can do to alleviate that position is to give them such special increase of pay as may be desirable, and, as far as you can, to make them as happy and as comfortable as possible.

We now come to the third question, and I think the third point is one which perhaps is even more important than the other two, and that is, "the question of the future." What are you going to do in the future? You are increasing the number of cadets very largely, so that you may have 1,000 lieutenants. In a few years you will be in the position of finding that you have this larger body of men in the rank of lieutenants but the same number of promotions. You can not increase the number of 23 promotions every year, however large your lieutenants' list may be. You have got only 2 men in 15 to be promoted in every case. This is a subject of the greatest difficulty, but I venture to think that the suggestion I threw out three years ago ought to be seriously considered and tried as an experiment. My suggestion was that the only way of meeting the difficulty was by an optional retirement of a limited number at an early age. When a man reaches 32 or even 30, you ought, with the consent of the Admiralty, to give him the power of an optional retirement. If you do this you will allow him at a comparatively early age to seek some other position in life before he becomes too old. I know it will be said in answer to this, "But your best men will go; your best men will be picked out for other appointments and you will lose them." I quite admit that this is a danger, but it is a danger not at all to be compared to that of having an enormous body of men discontented and dissatisfied.

The Navy must be kept up to its full efficiency; but if the body of naval officers from whom you draw your supplies to command your Navy is not maintained in a state of efficiency, and if they are allowed to become discontented and dissatisfied, it will be a terrible thing for this country.

I would venture to make a suggestion, that the First Lord of the Admiralty should appoint a committee of some of the best men in the Navy, together with an accountant and an actuary, and that this question should be thoroughly solved. It must not be shelved.

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* Because captains who reach the age of 55 without promotion must retire; see page 264, No. IX.

Lord Elphinstone, a retired naval officer, answered Lord Sudeley on behalf of the Admiralty, the following being extracts from his remarks:

> Turn whichever way you will, look at this question in whichever way you will, you are met by this problem, how are you to pass a list of 1,000 lieutenants into a list of 270 commanders? By no human ingenuity can you do that; you can not insure that every one of them shall enter into commander's rank. Upon that subject I think I can not do better than quote the words which were used in the debate on the former occasion, in 1888, by a noble Lord whom I do not see present, Lord Camperdown. He said, "With regard to the passing of 1,000 lieutenants on to the list of commanders, it is quite true it is impossible to promote 1,000 lieutenants into a list of 250 commanders, and therefore your Lordships must recognize at once as absolutely certain the fact, that a large number of lieutenants would never be promoted, and that by no scheme that human ingenuity could ever devise would it ever be possible to effect that object."
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> That is perfectly true; as his Lordship said, by no scheme which human ingenuity can devise will you be able to pass a list of 1,000 lieutenants on to a list of, now, 270 commanders. * * *
>
> It may seem hard, and at the first blush you may say that it is very hard that a lieutenant should not be allowed to retire, even if he wishes to do so, before he is 40, but we have to consider at the Admiralty what are the requirements of the service.
>
> We require the full number of 1,000 lieutenants, and until that number is reached we can not permit retirement, except, of course, where there are special and exceptional circumstances.
>
> Where there are special circumstances in the cases each of them would be inquired into by the Admiralty itself; but at the present moment, with the list below its full strength, we can not allow of any retirement. The noble Lord has suggested that retirement should be allowed, if they wished, at 32; but I would submit that after the great expense to which the country has been put in the matter, this can not be seriously advocated. At present the whole of the lieutenants are employed, and instead of the sublieutenants' list being of any assistance to the lieutenants' list, some four or five lieutenants are actually employed at this moment in doing sublieutenant's duty. * * * The requirements of the Service have very largely increased of late. Until the various lists are up to their full number there can be no question of voluntary retirement, and even then, when the lists are up to their full strength, I do not hold out the slightest prospect to my noble friend that retirement at 32 should be allowed voluntarily on the part of lieutenants. * * *
>
> I would like to point out that the position of lieutenants with regard to promotion is much more favorable now than at any time during the last 20 years.
>
> The proportion of promotions was formerly 1 in 15; previous to 1887, 2 in 9; since 1887, in consequence of the increased number of commanders, 2 in 7. Between 1870 and 1887 there were 418 promotions, or, roughly speaking, 21 a year; from 1888 to the present time there have been thirty a year. In selecting a batch of officers for promotion, the Admiralty always take care to select a certain number who can become flag officers.
>
> But this difficulty of promotion is one that exists everywhere. It is not peculiar to the English Navy; it exists in the Navies of every foreign power; they have all met with the same difficulty. But our average time for the service of sublieutenants is much less than that in any foreign Navy. * * *
>
> Although it is quite true that the Admiralty are much occupied at present, they do propose making a further and a careful inquiry into the position of the lieutenants with a view, if possible, of improving it, not through the medium of a committee, but within the Admiralty itself. The Admiralty are fully cognizant of the unfortunate position in which senior lieutenants are placed, and are most anxious, if possible, to improve their status.
>
> Therefore, the matter will be very shortly gone into.

The above debate shows the condition of the personnel of the executive branch, after a system of promotion and retirement which has been in operation for 20 years.

It should be noticed that Lord Sudeley does not ask that more lieutenants be promoted; on the contrary he distinctly admits that as being out of the question. He merely advocates the bettering of the condition of that large number who must retire as lieutenants, because the efficiency of the service is bound to suffer if important duties are intrusted to men who not only have lost all hope of preferment but who are underpaid and badly treated.

This also is the general tone of the press, a service journal putting it in this way:

> The object with which the State enters a number of gentlemen in the executive or any other branch of the Navy is to perform certain duties. For that purpose it establishes various grades, but it is manifestly absolutely impossible, that every candidate entered can rise to all or even a large proportion of those grades. The State does not so contract, and no such obligation, either expressed or implied, is entered into.
>
> The policy of the lieutenants as a body is surely to grasp and accept the fact that promotion is for many of them impossible, and to devote their energies to an amelioration of their pay and position, and an addition to the number of desirable appointments open to them. We have always advocated a progressive rate of pay for naval lieutenants. We strongly recommend the Admiralty to at least put the senior lieutenants on a footing of equality with officers of the civil branches of equal age in regard to pay.
>
> It is manifestly impossible, as we have said, that the State can promote all naval lieutenants, and it is certainly under no obligation to do so, but we are decidedly of opinion that the senior officers of that rank are in equity and fairness entitled to increased remuneration.
>
> We advocate their being remunerated on a sliding scale according to length of service.

The condition of the personnel is now agitating not only the Admiralty and service in general, but also the public, and principally for two reasons: First, the stagnation of promotion from the lieutenants' list, and, secondly, that very few of those who arrive on the captains' list will obtain flag rank. To remedy these evils with a due regard to finance is an exceedingly difficult problem, and its attempted solution will be watched with interest by all naval officers and persons interested in naval matters. An English service journal writes as follows:

> The letters that have been appearing in the press from lieutenants show a sort of apathetic recognition of their present position, and ask only that it may be made as little burdensome as possible by increase in their pay and decrease in their duties. In effect, they admit that long service in a subordinate rank is bound to be their fortune, and that if only they can reach the goal of £300 a year to retire on at the age of 45 their highest hopes will be met.
>
> We hear nothing from the captains promoted to that list, with the certainty that after a few years they will be compulsorily removed from it. They, too, must have fixed their minds on the time when they shall be free, with the largest attainable pension attached to their freedom.
>
> In short, the different ranks have settled down to the apparently inevitable, and have lost that eagerness for advancement to the highest ranks which used to be the animating spirit of the naval officer. * * *

> We want ambitious officers, who see before them some prospect of having their desires gratified. The very moment it becomes certain that they can not be gratified they should be allowed to retire from the race with credit for the space they have passed over in the running. * * * It is on our captains more than on any other body that England would have to depend if war broke out, and the great majority of them are compelled to serve with the certainty that early retirement is the best thing for them, unless they can cling on for sake of an extra annuity when the time comes. If it be healthy that our ships should be generally commanded by disappointed men, then promotion in the Navy is healthy, but not otherwise.

As regards promotion by selection, it is but natural that heart-burnings and disappointments should be frequent and deep, seeing that less than 30 lieutenants are annually selected from 1,000 for the commanders' list, nor is there any dearth of accusations of favoritism in these selections.

It is very rarely maintained, however, that incompetent lieutenants and commanders are promoted, but simply that as good and sometimes better men are passed over.

Admiral Colomb describes the system in this way:

> The commanders' list is a kind of winnow for lieutenants and perhaps a good many grains of wheat are blown back accidentally, while some chaff may find its way in amongst the wheat. If chaff finds its way to the commanders' list, there is a second winnowing process before it in the captains' list; but for the grains blown back accidentally to the lieutenants' list there is little or no prospect.

There is no demand to do away with selection entirely, but to surround it with safeguards so as to minimize the chances of injustice. It is recognized that ships and fleets to be efficient must be commanded by men of youthful mental and physical vigor, and no proposition is advanced to obtain these in any other way than by selection.

That the system at all events secures comparatively young men for the higher ranks, the following table will show, and it must be added that the ages of the junior captains, 42½, and of the junior commanders, 36¾, have increased since 1887, and are now considered too high:

	Average age of first five.	Average age of last five.		Average age of first three.	Average age of last three.
Sublieutenants	23	19¾	Rea-admirals	58	55
Lieutenants	44½	23	Vice-admirals	59	57
Commanders	47	36¾	Admirals	61¾	60
Captains	51	42½			

The youngest two rear-admirals are 48 and 49 years of age, respectively, and the youngest two vice admirals (excepting the Duke of Edinburgh, who is 47), 55 and 56.

The average of the last five commanders, 36¾ years, gives an idea of the ages of the lieutenants who stand a chance of being promoted. It may be taken for granted that the lieutenants who average more are out of the race.

Lieutenants and commanders who have been overslaughed once, are not often promoted, only in very exceptional cases. If an officer's merits have been overlooked or he has the luck to be in the right spot and performs conspicuous service, he then obtains promotion, not otherwise.

Officers who have been overslaughed are detailed for duty precisely as before, unless there should be some specific reason for giving them special duty.

If officers are selected for their special fitness, for duty on shore, they take good care to leave these shore positions and get to sea in time to come within the laws of promotion. Should they remain ashore beyond this time, they would be retired for nonservice at sea. The present assistant to the Director of Naval Ordnance and the commander in charge of the Gun Factory at Woolwich are examples of the last clause. They have sacrificed their chances of promotion by voluntarily keeping their present position beyond the usual time of shore service.

The Admiralty have the power to employ retired officers, but very few such officers are actively employed.

FRANCE.

A Presidential Decree of October 21, 1890, abolished the Admiralty Council (*Conseil d'Amirauté*). Page 274 of No. IX explains the composition of this Council, and a further reference to page 280 will show the enormous influence it exerted on the personnel, by being intrusted with the preparation of the *tableaux d'avancement*. In the execution of this last exceedingly difficult task the Council (which had existed since 1824) had given general satisfaction up to about the year 1880. In the last 10 years, however, it was accused of favoritism, and, above all things, of nepotism of the most flagrant kind. No officer who had not relatives or at least intimate friends among the higher officers was considered to stand any chance of being promoted. In the programme of reforms demanded by the so-called *Jeune Ecole* of the navy, the abolition of the Council had a conspicuous place, nor were many voices raised in opposition to this demand.

On October 21, 1890, the Minister of Marine wrote a letter to the President requesting that the Council be abolished, and assigning, among other reasons, that "it has for some time been a question whether it would not be well to have on the Board charged with the preparation of the *tableaux d'avancement*, a larger number of officers of high rank who have recently been in contact with the officers proposed for the *tableaux*, and who thus possess a better and more complete knowledge of the candidates whose worth they are to decide and whose interests to defend. The wish of the service in this respect admits of no doubt, and latterly the Naval Committee of the Chamber of Deputies has called my attention to the urgent need of this reform."

In accordance with the wishes of the Minister of Marine, the President then abolished the Admiralty Council and at the same time created three new offices, whose incumbents were to be called Inspectors-General of the Navy, and were to be two Vice-Admirals and one Rear-Admiral, all three on the active list.

These Inspectors have no executive authority, but they inspect and report upon the entire personnel and material of the Navy. They are sent from Paris on tours of inspection, and the work is divided among them so that they do not inspect as a Board but individually. They are appointed by the Minister for two years, can be reappointed for two years, but for a third term only after an interval of one year. Before the expiration of the term of two years they are not to be removed except as required by the exigencies of the service.

The following is a translation of the presidential order creating a "Board to classify the officers of the different corps of the navy for promotion to the next higher grade." Only that part of the order relating to officers of the executive branch is translated:

ARTICLE 1. A Board is hereby created, charged with the annual preparation of the *tableaux d'avancement* for those officers of the Navy who are promoted by selection and with the arrangement on these *tableaux* of the names of the candidates in order of merit.

ART. 2. This Board will be constituted as follows: For all corps, the Inspectors-General of the Navy and the Director of the Personnel,* will be members; to these will be added, for officers of the executive branch, the following: Flag officers and captains who have been the immediate predecessors in command of fleets and divisions, of the officers in command of those fleets and divisions at the time of the formation of the *tableaux*.

If one of the flag officers above mentioned is prevented by a serious cause from serving, he will be replaced by a flag officer having served under him, or by his chief of staff, provided this officer is not of a lower rank than that of captain.

ART. 3. Every year, after the reports of the general inspections, the individual reports, and the proposals for promotions coming from competent authorities, have reached the Bureau of the Director of Personnel, the Minister will designate those officers and officials who, besides the permanent members, are to form part of the Board of Promotion, and will issue the order for this Board to meet.

ART. 4. Flag officers, captains, and officers of the civil branches of the same relative rank, are not included in the work of the Board.

ART. 5. No one can be promoted by selection, whose name is not placed upon the *tableaux d'avancement* by the Board, or by the Minister, according to the following article.

ART. 6. For acts in time of war, extraordinary services, special missions, or isolated commands, the Minister may place the names of those officers on the *tableaux d'avancement* who have deserved such a reward.

ART. 7. The number of names to be inscribed on the *tableau* for each grade shall be the sum of two numbers, the first of which is the number of vacancies *certain* to occur in the next higher grade, from retirements for age, during the next 18 months, and the second the number of *probable* vacancies to occur during the next 12 months based on the average vacancies of the past 5 years.

Officers whose names remain on the *tableau* for 2 years will have their merits again discussed by the Board, and the latter may remove their names if it sees fit to do so.

The names of officers which have been on the *tableaux* less than 2 years, can not be removed.

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* The Director of the Personnel is a Rear-Admiral.

> The names of officers newly inscribed on the *tableaux* shall be arranged in order according to the preference of the Board, but *after* the names of those already on the *tableaux* and of those carried along from the *tableaux* of the preceding year.
>
> The Board, with the approval of the Minister, may remove the names of officers from the *tableaux* for serious offenses.
>
> ART. 9. The Board must receive all official documents necessary to its labors.
>
> ART. 10. The Senior Vice-Admiral on the Board shall be its presiding officer.

Concerning the above order, the opinion of a German naval officer as expressed in the *Marine-Rundschau* (a monthly devoted to naval matters, appearing as a companion to the official German Naval Gazette), will be of interest, especially so when it is remembered that in the German Navy promotion is by seniority alone:

> If anyone has cherished the hope that by the appointment of this new Board all harshness and injustice in the promotion of officers by selection would be done away with, he will be disappointed, nor, as a matter of fact, are any such illusions held. Even if the Admiralty Council was accused of inordinately guarding the interest of a certain class of officers and of too much partiality, it would show a mistaken idea of the state of affairs to ascribe the discontent of the corps of officers solely to the practices of the Council in preparing the *tableaux d'avancement.* The causes of this discontent are in the generally defective system of promotions, which prevents an officer, who advances by seniority alone, from reaching the higher grades. If the number of those who can be promoted annually will remain so small, compared to the entire number of officers, as has been the case during the past few years, the task of selecting from the large number of able and deserving officers will be so difficult that no measure can be thought of which will be just to every one.
>
> Promotion by seniority alone is excluded by the ages of those at the head of the lists; a selection must be made out of the younger element, of men who can take command of ships and squadrons while yet in physical and mental vigor. The new Board may make a different choice of officers, but it will happen the same as with the Admiralty Council, that every member of the Board will have a protégé whom he will propose and whose advancement he will further with all his power.
>
> It does not seem that the creation of the new Board has improved matters much.
>
> The tremendous influence of the Inspectors-General, who have a voice in all naval matters, can lead to abuses just as much as the partiality of the Admiralty Council, which, if it did show a preference for the sons and relatives of admirals, was at all events happy in its selections, as the ability of officers proposed by it has never been questioned.

It may be that the predictions of the writer in the Marine-Rundschau will be verified, but in one respect the appointment of the Board has already borne fruit.

One of the most urgent demands made by naval officers was that the names of those placed on the *tableaux d'avancement* should be selected from the first quarter of the list; for instance, no lieutenant below No. 175 should be placed on the *tableau*, there being seven hundred lieutenants.

M. de Lanessan, a member of the Chamber of Deputies, explains this demand very well in *La Marine Française au Printemps de* 1890. He states that a distinguished naval officer writes to him as follows:

> In the Navy all officers of the executive branch, with few exceptions, graduate from the Naval School; all have about the same instrucion, and the majority fulfill the conditions required for promotion to the next higher grade. It is evident that under

these circumstances selection should be very limited. An officer who in time of peace gains 4 or 5 years over his comrades, should be very well satisfied, and he should have given evidence of exceptional ability as deck officer and in command.

To effect this, it is only necessary that the Minister should fix a limit beyond which an officer can not be put on the *tableaux* except for war service.

This limit should be five times the number of officers who pass to the next higher grade each year, that is to say about 180 for lieutenants, for every year 32 to 35 commanders are made. No one below No. 180 on the list should be put on the *tableau*. Every one thus put on would gain 3, 4, or 5 years over his comrades, of which there would be scarcely any complaint. To institute this change neither a law nor a Presidential Decree is needed, a simple order from the Minister will suffice, and if he gives this order he will receive the thanks of a large number of officers who to-day are deeply disgusted.

M. de Lanessan adds:

It is not rare that under actual conditions officers gain 7, 8, and even 10 years over comrades of equal worth, but not fortunate enough to have powerful protectors.

It is necessary to prevent as much as possible abuses, which, although they are due to the human heart, are not the less prejudicial to the higher interest of our Navy.

This was written in May, 1890.

An examination of the *tableaux d'avancement* in the Navy Register for 1891, the first prepared by the new Board, shows as follows:

On the *tableau* for promotion to captain there are the names of 20 commanders, and not one of these names is below No. 86 on the list of 200 commanders.

On the *tableau* for promotion to commander, there are the names of 18 lieutenants which were put on this year, and not one of these names is below No. 178 on the list of 700 lieutenants; but of the names of 9 lieutenants who are on the *tableau* from last year two are below No. 178, one being No. 219 and the other No. 247.

On the *tableau* for promotion to lieutenant, there are the names of 20 ensigns, and not one of these names is below No. 103 on the list of 420 ensigns.

So that the new Board in the preparation of the first *tableaux* has virtually yielded to the demand to confine its selections to the upper parts of the lists. For this concession, the officers appear to be duly thankful, but they ask that the matter be hereafter not left to the discretion of the Board. Another cause of complaint is that the Presidential Decree fixes the same rule for determining the number of names to be placed on the *tableau* for each grade. But since the promotions from commanders are *all* by selection, from lieutenants *one-half* by selection, and from ensigns *one-third* by selection, it is claimed that if the present rule is just in determining the number of commanders on the *tableaux* the same rule puts on twice as many lieutenants and three times as many ensigns as should be there.

The *Jeune Ecole* also demands that promotions to lieutenants be by seniority alone. Otherwise there is no demand to do away with selection, for as one officer expresses it, "there must be an incentive in time of peace as well as in war."

The following table is compiled from the Navy Register for 1891:

	Average age of first five.	Average age of last five.		Age of senior.	Age of junior.
Midshipman	23	22	Rear-admiral	56	59
Ensign	27½	22	Vice-admiral	59	55
Lieutenant	46	27			
Commander	56	43			
Captain	57	49			

A comparison of the Registers of 1890 and 1891 shows that during the year 1890 there were promoted from each grade the following numbers:

Midshipman	65	Commander	19
Ensign	62	Captain	9
Lieutenant	36	Rear admiral	4

The condition of the personnel is depicted in numerous articles by M. Weyl, an ex-naval officer, the foremost authority on naval matters in France, if not in Europe, the pith of which is as follows:

> Our officers are too old, their promotion is too slow. We treat officers of the Navy like those of the Army and yet the conditions of life in the two services are entirely different. The seaman is continually in the field, and in his noble profession there is considerable waste. If you want good officers you must not keep them in a subordinate capacity too long. An officer of forty-five should not stand watch and perform the same duties as young men of twenty-odd. It is to the interest of the country to have only vigorous officers on the active list, but you can not get rid of the others without offering them some compensation. Certainly in a country like ours, where there are so many civil positions at the disposal of the government, it should not be difficult to find employment for naval officers, who, although a burden to the government, while on the active list, would thus become of use.
>
> Let it be done with them as with petty officers, a certain number of positions in the Treasury Department be annually reserved for them, a certain number of consulates be placed at the disposal of the Minister of Marine; and the head of the lieutenants list will soon get into a reasonable condition. While instituting these reforms, we would at the same time cut down the number of officers on shore duty, and reduce the complement of officers on shipboard.
>
> The longer an officer remains on shore the less fitted he becomes for his profession. The English get along with fewer officers in proportion to the number of ships than we, for the simple reason that their personnel is younger and they can thus get more work out of it.
>
> The retiring age in all grades, except those of flag officers, must be cut down. To this it is objected that the effect would only be transitory, but it must be acknowledged that it would at all events make the corps of officers younger. It would not be judicious to apply the new law suddenly; the new retiring ages could be reached by progressive steps, in 3 or 4 years, for example.
>
> Of course on the day on which the law which I advocate will have had its full effect promotion will again become slower, and we shall again be in a difficult situation; but in the mean time our ships will have younger officers and the real object of the new legislation will have been attained.
>
> Furthermore, provided the system of earlier retirement in grade remedies matters for a number of years, it is all that can be expected; in the future it can again be modified as occasion demands.
>
> "Sufficient unto the day is the evil thereof," and it can not be denied that the present situation is intolerable.

The entire press, professional and otherwise, is taking the liveliest interest in this question of the efficiency of the personnel, and generally favors the demanded reforms. Nor is it at all likely that anything could be done without this powerful backing.

The following is a condensed extract from *La Marine Française au Printemps de* 1890. M. de Lanessan* is again quoted because he is not a naval officer, but a civilian and member of the Chamber of Deputies, and because his views are a fair exponent of the views of the press. What follows refers to officers of the executive branch only:

> The results of the present state of affairs are two: In the first place, if war were to break out to-day it would be impossible to give all our vessels their proper complements of officers; and, in the second place, promotion is so slow, that a spirit of profound discouragement has seized our entire personnel.
>
> There is no profession which requires greater physical and mental strength than that of the seaman; there is none which requires more constant intellectual work, and I must say, without attempting to flatter our officers, that with rare exceptions they are far from meriting the reproach of idleness with which they are at times charged.
>
> Only those who have lived on board ships of war can appreciate the fatigues, the responsibilities, and the annoyances which prematurely exhaust the strength of a naval officer. Only such can know with what resignation and devotion our officers submit to the loss of all pleasures of family and of society, with what calm resolution they confront all the dangers to which they are incessantly exposed, with what pride, the result of their profession, their education, and their patriotism, they carry across the ocean the flag and name of their distant country.
>
> And yet there is not another corps of officers in France in which promotion is so slow.
>
> An examination of the Naval Register shows that an officer graduated from the Naval School, well recommended, decorated for his services, his good conduct, and his work, scarcely ever becomes a commander before the age of 40; that is to say, he must serve in the subordinate grades for at least 22 years.
>
> This situation is the more distressing in that it often condemns the senior lieutenants to live in the ward-room of large ships with officers of the same grade 15 to 18 years younger, and with ensigns still younger, and doing the same duty.
>
> It is evident that such a state of affairs is bad for the officers and detrimental to discipline.
>
> It is hard for a man of 45 to be compelled to do the same duty as a young ensign of 23 or 26. Watches which the latter stands with the ardor of a neophyte are for the former annoying and fatiguing drudgery—above all things, if bad weather or the difficulties of manœuvres do not awaken that love of his profession which always lies dormant in the heart of the seaman.
>
> During the first 10 years one supports without difficulty all troubles, although they were by no means foreseen when entering the service. These are merely passing shadows, thrown by accident or ill fortune over a future which the officer still sees shining before him and on a present which his youth illumines, but as years roll on the shadows thicken, and the solitary reveries of the night watches turn i
> painful nightmares.
>
> That promotion to which up to now the officer had scarcely devoted a thought
> comes the incessant preoccupation of his vigils. Upon leaving the Naval School, you
> and vigorous, his ambition scarcely halted at the two stars of a rear-admiral; lat
> when wind and weather have worn out for him innumerable lieutenant's stripes,

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* Since the above was written M. de Lanessan has been appointed governor of Ton

ambition becomes narrower and he himself soured and discontented. At what age, in how many years, will he be a commander and released from watches and drudgery? From this moment disgust with the profession insinuates itself little by little into the most robust hearts; and as at the same time age is reducing his strength, the officer loses in value every day. When he arrives at the higher grades he is already anxious for repose.

This picture, I will hasten to say, does not apply to all our officers. Many resist all annoyances and all hardships, and maintain, in spite of age, their youthful ambition and strength; but I would that promotions were such that exceptions were the rule, and that all our officers could arrive at the higher grades sufficiently young to enjoy for a long time the plenitude of their powers.

It is evident [concludes M. de Lanessan], first, that in order to meet all the requirements of our Navy, the number of officers must be increased; second, that to increase the promotions from the grade of lieutenant the numbers in the higher grades must be increased; third, that the rules for promotion by selection must be changed so as to have fairer selection; fourth, that measures must be taken to have ensigns spend more of their time at sea and to give them and midshipmen more rapid promotion, the latter passing not more than 2 years in grade.

To explain the fourth demand it must be added that M. de Lanessan maintains that ensigns should spend nearly all their time at sea, which is by no means the case now.

It will be noticed that M. de Lanessan would hasten promotion among the subordinate officers by increasing the numbers in the higher grades. M. Weyl maintains that this would only remedy matters for a very short time, and insists that the retiring ages must be cut down.

The Committee appointed by the Chamber of Deputies to investigate the state of the personnel and suggest a remedy has embodied both ideas in its report.

The table below shows the present allowance of officers and retiring ages and those recommended by the Committee:

	No. allowed at present.	No. proposed.	Present retiring age.	Proposed retiring age.
Vice-admirals	15	15	65	65
Rear-admirals	30	30	62	60
Captains	100	120	60	58
Commanders	200	220	58	54
Lieutenants, first class	350	375	53	50
Lieutenants, second class	350	375	53	50
Ensigns	420	400	52	45
Midshipmen	140	160	....	....

It is also recommended that the terms *aspirant de première classe* and *aspirant de seconde classe* (see page 279, No. IX) be suppressed and replaced by *aspirant* and *élève*. *Aspirants* will have the relative rank of second lieutenant in the Army, and be promoted to ensign after 2 years; *élèves* will have the relative rank of a *sous lieutenant*, and become *aspirants* after 1 year on board the School ship of Application.

The report adds that the new retirement law will be applied to those officers only who are promoted after the passage of the act.

The two greatest naval powers in the world promote their officers on two radically different principles.

England begins with absolute, unrestricted selection, and continues this system to the grade of captain, and then from captain up changes to strict seniority.

France begins with partial selection, then gradually increases the element of selection until from commander to captain it is all selection but with restrictions, and then from captain up, selection absolute and unrestricted.

It is also interesting to observe that although the discontent in both services is great, yet neither service demands radical change in the systems.

ITALY.

In No. IX, on pages 295, 296, and 297, the general system of entry into the corps of officers, a table of grades, numbers in each, and ages for retirement are given; also sea-service requirements for promotion. The paragraph relating to the promotion of sub-lieutenants and grades to and including that of commander is incorrect.

The method of promoting to sub-lieutenant and higher grades is as follows:

Sublieutenant.—All promotion to sublieutenant is by seniority.

Lieutenant.—Promotion to lieutenant in time of peace is two-thirds by seniority and one-third by selection; in time of war, half by seniority and half by selection. Usually the sub-lieutenants of the same date are sent to Leghorn for a post-graduate course, ending with an examination which determines their standing on the naval register; but their standing is also fixed by a competitive examination, whether the post-graduate course is gone through or not.

Lieutenant-commander.—Promotion to lieutenant-commander in time of peace is half by seniority and half by selection; in time of war, all by selection.

Commander.—All promotion to commander and higher grades is by selection, both in time of peace and war.

The only exceptions to the above rules are: (1) For signal gallantry; (2) when in presence of an enemy vacancies must be filled.

The system of promotion resembles the French very closely.

Each year the Superior Council prepares a *promotion table* for each grade from which officers are promoted by selection. The Minister of Marine may add the name of an officer to this table who has distinguished himself by any specially meritorious action, by the accomplishment of some special mission, or by any extraordinary service, particularly in the case of captains of ships in foreign waters and of officers directly under the orders of the Ministry.

No officer can be promoted by selection unless his name is borne upon the *promotion table* of his grade.

Promotion tables are not made public.

When promotion is from a grade having both seniority and selection, these two qualifications are alternated in making the promotion.

The Superior Council consists of three officers of flag rank, of a captain as secretary, of all the Chiefs of Bureaus in the Ministry, and of the Chief of Staff in the Ministry.

The present composition of this Council is as follows:

Vice-admirals	2	Medical inspector	1
Rear-admirals	5	Pay inspector	1
Captains	1	Colonel Army engineers	1
Inspectors of engineers	2	Chiefs of Bureaus (civil)	

The Council, in preparing promotion tables, is guided altogether by the official reports made upon officers by their superiors, and forwarded through the regular official channels to the Ministry, so as to reach there by December 1 of each year. (In future reports are to be made twice a year.)

Reports are made exceptionally when a ship goes out of commission, when a naval force is disbanded, when an officer is detached from a vessel, when an officer is detached from any duty on shore. When, however, duty on board or on shore has been for only 2 months or less, no report is sent in.

For officers off duty no report is sent in, their last report being referred to if necessary.

REGULATIONS FOR REPORTS ON OFFICERS.

(1) For officers under the rank of captain the form of record follows, marked A; for captains is a special form, marked B.

(2) These reports concerning officers aboard ship are made by—

(*a*) The commanding officer of the vessel.

(*b*) The Commander in Chief of the naval force on the commanding officers of vessels, on executive officers, and on any superior officer (officer above lieutenant and under admiral) serving under him.

(*c*) The Chief of Staff of a naval force on any officer of the staff.

(*d*) The Commander in Chief of a Department, or by the Chief of Bureau of Military Service (personnel) in the Ministry on commanding officers of vessels dependent respectively on the Commander in Chief or on the Ministry.

Reports concerning officers on shore are made by—

(*a*) Chiefs of corps, office, duty, etc., on officers serving under them.

(*b*) Commander in Chief of Department on these Chiefs.

(*c*) The President of the Superior Council on officers attached to the Council.

(*d*) Chiefs of Bureaus in the Ministry on officers attached to their Bureaus.

(*e*) The First Aide-de-Camp of the King and Princes on officers serving on the staff.

A. (*Officers under rank of captain.*)

Royal Italian Navy: ——— Maritime Department; ——— (squadron, corps, or office) individual record of (rank):

Mr. ——— (name in large letters), son of ———, of ———, born the ———, at ———, province of ———; religion ———; national decorations ———; foreign decorations ———.

Service and sea duty: Entry into the service ———; date last promotion ———; total sea service ———; sea service in command ——— years, ——— months, ——— days. Necessary sea service for promotion to ———, in grade of ———. Sea service from that time up to date ———.

Intelligence and attainments:
  Intelligence
  Disposition to study
  Knowledge of regulations
  Scientific attainments
  Knowledge of languages
  Technical and executive ability.

Professional qualifications:
  Manner of doing duty
  Manner towards superiors
  Manner with equals
  Manner to inferiors
  Care as to uniform
  Special duties since last report
  Manner in which they were performed
  Instruction
  Aptitude for command.

Conduct and character:
  Conduct on duty
  Conduct off duty
  Character.

Physical condition, courage:
  Physical condition
  Aptitude for ship life
  Sight
  Courage.

Special characteristics for superior officers:
  Manner of commanding a vessel with regard to war and seamanlike qualities.
  In which best
  In which defective
  Special attributes.

General:
  Whether better adapted to sea or shore service.
  If meriting extraordinary promotion.
  Any other characteristics which convey a good idea of the individual.

The undersigned believes Mr. ——— worthy of promotion to the grade of ——— by ——— (seniority or selection).

The undersigned believes that Mr. ——— is not deserving of promotion.

Date ———.

First indorsement (by second Admiral of Squadron or Commandant of Dockyard).

Second indorsement (by Commander in Chief of Department or Naval Force, or Chief of Bureau of Military Service).

Final indorsement by Superior Council.

* * * * * * *

The Superior Council having examined the within record and all other documents referring to Mr. ——— declare him ——— for the grade of ———.

The Council also declares that the said officer is worthy of being placed upon the promotion table ——— (by seniority or by selection is here expressed).

Date ———. Signatures.

B.—*The Commander in Chief (of Squadron or Department) the Second in Command.*

Report upon Mr. ———, captain, on duty ———.

Physical, moral, and intellectual qualities.—Report should state whether the officer is physically sufficiently strong to perform the duties of his grade or present command in time of war. Should also show if he possesses all the qualities necessary to the captain of a ship, head of corps or office, etc., specifying his deficiencies or preëminent qualifications.

Instruction, professional ability, manner of doing duty.—Show whether he possesses requisite amount of necessary qualities for duty as captain of a ship, or for accomplishment of such diplomatic matters as may be intrusted to him.

Whether he possesses the above qualities sufficiently to have confided to him the command of a naval force in time of peace and in time of war.

To the above should be added any details or information which will inform the Ministry of the real usefulness or worth of the officer, and the best disposition that can be made of him and of the vessel he commands.

Recommendation.—Should state in explicit terms whether the officer deserves promotion, and if so, whether he should pass over those ahead of him on the list.

The columns of the report form A must be filled out concisely, but clearly and explicitly.

The report on a captain must be entirely written by hand, the form B being given only to indicate generally what the report should contain and the order in which the contents should be arranged.

When the commanding officer of a vessel is not a captain then form A is always used.

When an officer is ordered to a vessel, two copies of the necessary form are sent with him, supplementary copies being sent later if required by the length of the cruise.

When these forms are needed on shore, by reason of an officer being transferred, the superior who should fill out the forms makes requisition for them.

When a Commander in Chief of Department or Squadron receives an unsatisfactory report concerning an officer he must personally or in writing, if the officer is absent, warn him to improve.

For Admirals in subordinate commands a report is made by the Commander in Chief, who follows, in general, form B, but with such additions as he considers required by the higher rank.

All reports are made out in duplicate, one copy being kept by the Commander in Chief of Department or Squadron, the other sent to the Ministry and preserved in the Bureau of Military Service (personnel).

On the disbanding of a naval force, all reports remaining in the Admiral's office on board the flagship are sent to the Commander in Chief of the Department to which the officer concerned is attached. (Each officer of the Italian navy belongs to one of the three Maritime Departments and when on shore is always ordered to duty in that Department.)

In case an officer is transferred from one Department to another his records are sent under private seal to the Commander in Chief of his new Department.

Reports and all correspondence concerning them are confidential; no copy or extract from them can be given without an express order from the Ministry.

It can readily be seen that the Superior Council has ample data for judging of the merits of officers.

Whatever abilities, accomplishments, or deficiencies an officer may possess are as well known at the Ministry of Marine as on board his ship, for the reports are continuous from the moment of his entering the service.

The verdicts of the Council apparently give general satisfaction, for charges of favoritism and injustice are very seldom made.

A comparison of the Navy Registers of 1890 and 1891 shows as follows:

The junior rear-admiral in 1891 was No. 7 on the list of 35 captains in 1890.

The junior captain in 1891 was No. 21 on the list of 56 commanders in 1890.

The junior commander in 1891 was No. 34 on the list of 70 lieutenant-commanders in 1890.

The junior lieutenant-commander in 1891 was No. 27 on the list of 222 lieutenants in 1890.

Thus all promotions by selection were made from officers well up in the lists, so that, other things being equal, length of service has due weight.

In the case of promotion to the grade of rear-admiral public opinion in the service usually names the lucky man before he has been officially chosen, and sometimes many months before, as often months elapse in the careful consideration of different claims to such an important promotion.

The following table is compiled from the Navy Register for 1891:

Grade.	Average age of first five.	Average age of last five.
Captain	51	46
Commander	46	43
Lieutenant-commander	44	41
Lieutenant	43	25½
Sublieutenant	25	20

Senior vice-admiral, 63 years of age, and been 14 years in grade; junior vice-admiral, 54 years of age; senior rear-admiral, 56½ years of age, and been 6 years in grade; junior rear-admiral, 53 years of age.

The system of promotion has been in force since 1858, first in the Sardinian and then in the Italian Navy, and the fact of its remaining practically unchanged for 33 years would seem to be an indorsement of its value.

AUSTRIA.

In No. IX, page 309, the method of recruiting the corps of officers of the executive branch is described and a table shows the different grades and numbers in each grade.

The following sea-service qualifications are required for promotion:

Sea cadets, first class, may be promoted to sub-lieutenants after having given practical evidence of their efficiency, and for this the two years' sea service required of them as sea cadets, second class, is sufficient.

Sub-lieutenants must have 2 years' sea service; lieutenants, 3 years' sea service, of which 1 year on board an armor-clad, and part of the 3 years as executive officer; lieutenant-commander, 1 year; but if necessary, the time passed in doing lieutenant-commander's duty while lieutenant can count for this; commander, 1 year.

An officer may be promoted to the next higher grade if in every way qualified, even without having fulfilled the above requirements of sea service, if this has occurred through no fault of his own, and especially if he has been detailed for other professional duty.

Promotion is practically by seniority alone.

In theory there is promotion by selection, as shown by the following extracts from the regulations:

Promotions from sea cadet, second class, to lieutenant, first class, inclusive, are in time of peace according to seniority alone.

Promotions from lieutenant, first class, to captain inclusive, are according to seniority, but in special cases, in peace as well as in war, are by selection.

Promotions from captain up are not governed by seniority.

Promotion out of turn is an Imperial favor, which may be obtained by very exceptionally meritorious services, but can never be claimed as a right.

Only officers of and above the rank of lieutenant, first class, can be proposed for promotions out of turn in time of peace, and officers so proposed must have distinguished themselves ashore and afloat by aptitude, good judgment, and absolute trustworthiness, and must have given evidence through scientific writings or special professional service that they will perform good work in a higher position and that their promotions out of turn will be really beneficial to the service. They must be among the first third of their grade. They must serve for two consecutive years on board one or more ships of a fleet doing the same duty, and during this time must be exceedingly well recorded in the reports of their superiors and be unanimously recommended for promotion by selection.

Proposals for promotion by selection are made to the Marine Section (Navy Department) by those officers having the authority to make reports on their juniors, and those forwarding such proposals in the course of official transmittal must make exhaustive comments thereon.

Those captains are promoted to the grade of rear-admiral who have shown conclusively while in command of a squadron, division, or torpedo-boat flotilla, or in command of a ship abroad, that they are fully qualified for the duties of a flag officer.

Rear-admirals can be promoted to vice-admiral if, while for some time in command of a squadron, they have given evidence of eminent qualifications. They may also be promoted without having had such sea service if while captain they have had command of a squadron.

Vice admirals are promoted according to the will of the Emperor.

The Emperor, in fact, has the right to promote officers by selection, but it is a right of which he never avails himself, like the "undoubted right of her Majesty to selection" in the case of the promotion of captains in the English navy.

So that it may be said promotion is by seniority alone.

Officers stationed at court, attachés to legations, or other specially employed officers are carried as in excess of the number allowed in their grade, but are promoted, if they qualify, with the man next ahead.

Lieutenants who wish to devote themselves to some professional specialty, may, if they show the necessary ability in their specialty and it be for the interest of the service, be promoted at the same time with the man next ahead, but at the same time be transferred to the list of officers for local duty.

Officers on local duty are those who have faultlessly performed all their sea duty, but are for physical reasons unable to go to sea and are yet capable of performing good and valuable duty on shore. They are promoted to the next higher grade after officers on the regular list of the same rank have been promoted.

Lieutenants who for personal reasons wish to forego promotion to lieutenant commander, but are in the first third of their grade and qualified for promotion, may apply to be transferred to the local duty list of lieutenant commanders, and will, if their request is granted, be so transferred when a vacancy occurs. The number of such applicants is restricted to eight.

The most interesting point of the Austrian system of promotion is that they have no examinations for promotion, but that an officer who arrives at the top of the list is judged altogether by his record.

Promotions are made on May 1, November 1.

Promotion Boards are constituted as follows: For sea cadets, first class, sublieutenants and lieutenants second class, one rear-admiral (president), two captains, two commanders, two lieutenant-commanders.

For lieutenants, first class, lieutenant-commanders, and commanders, vice admiral or admiral (president), two rear-admirals, four captains, but the two rear-admirals may be replaced by captains if necessary.

These Boards meet in Vienna, and their proceedings are confidential.

As a rule, they are called together during the first months of the year by the Marine Section, and the qualification lists and reports concerning those officers who, from their position on the Navy Register, will probably be promoted in the course of the year, are submitted to them, and further documents which can be of use to them in judging of the worth of candidates are also submitted, as, for instance. Reports of Inspections, if the candidate has had command of a vessel.

The President conducts the proceedings, and is careful that the qualification lists for as many years are considered as will enable the Board to form an exhaustive and correct opinion of the candidate.

As soon as the case has been sufficiently discussed and all doubtful points explained, the Board proceeds to vote, the junior voting first.

Voting must be in accordance with the conviction formed from the evidence and discussion thereon and must be in one of the following terms: Qualified; not qualified; not qualified at present.

The last vote is generally given when the candidate, although generally qualified, has not fulfilled certain conditions, such as sea service, or has been sick so that the reports have not been able to fully describe him, etc.

When the last two votes are given, or if an officer formerly reported "not qualified" is now reported "qualified," detailed reports must be made.

The majority of votes is necessary for a decision.

The junior member is recorder.

Every member voting in the minority has a right to accompany the report of the Board with a separate report explaining the reason of his vote.

The report of the Board, with all documents concerning the case, is forwarded to the Marine Section.

Promotion Boards also examine and report upon any proposed cases for promotion by selection.

They can also recommend for such promotion officers who have for a number of years been described in their qualification lists as "preëminently qualified for promotion."

For this purpose they can demand all documents relating to officers who are not likely to be promoted by seniority during the coming year, but who are in the first third of their list, also all documents relating to the officers who would be overslaughed by the proposed candidate. From a mature consideration of all such documents the Board makes its report whether it is really in the interest of the service to promote the candidate by selection.

The Marine Section requires periodical continuous reports on all officers.

These reports are most complete and exhaustive, and keep the department informed of the personal character, general ability, and special acquirements of every officer in the service; thus not only enabling the Promotion Board to decide upon an officer's fitness for promotion, but also indicating to the Department the suitability of any officer for particular duty.

The regulations state:

> The influence which these reports exert on the service and on the career of the persons described makes it the strict duty of those making such reports to become intimately acquainted with their subordinates, and to learn their characteristics, free of all prejudice, according to most conscientious conviction.
>
> For every injustice committed by a superior in such reports through superficiality, favoritism, or animus, he will be held to the severest accountability.
>
> Frank and fearless language must characterize the descriptions; they must be thorough and complete, showing no animus, avoiding all general, indeterminate, and fulsome expressions, using striking, terse language, and must enable superiors to judge the person described who do not know him personally.

Reports on officers up to and including the rank of captain are called "Qualification Lists."

Reports on flag officers and captains appointed commodores are called Chief Reports (*Haupt-Berichte*).

For each person concerning whom a Qualification List is made, a Qualification Register, corrected up to date, is kept at the Marine Section which contains a short history of the described and the Lists themselves in chronological order.

This Qualification Register shows age, religion, private circumstances, education, and studies before entering the service; date of entrance; private circumstances (whether married, how many children, financial condition, etc., of wife, etc.); decorations: national, foreign; fellow of any learned society; a synopsis of his duty, transfers, etc.; war campaigns, actions and other service; instruction after entry into service in any specialties; specialties; special acquirements not professional; writings for public print; accidents.

Under heading "instruction after entry in service" is given the year, duration, and result, the latter marked *good*, *very good*, *satisfactory*, or *unsatisfactory*.

"Specialties" include gunnery, torpedo, submarine mines, electricity, compasses, photography, army war school, university courses.

"Special acquirements not professional" includes any knowledge or acquirement requiring study or application, such as drawing, painting, music, stenography, telegraphy, horsemanship, gymnastics, swimming, etc.

"Accidents" includes getting ship ashore, collision, accidents in handling ammunition, etc.

Chief Reports are made out annually and must reach the Marine Section not later than January 31.

The persons who make these reports are (1) Chief of the Marine Section, (2) his representative, (3) the port admiral, (4) (on flag officers serving under him) the Commander-in-Chief of a Fleet.

They are all indorsed by the Chief of the Marine Section.

FORM FOR CHIEF REPORTS.

(1) Age and years of service.
War service.
(2) Characteristics in action.
(3) Characteristics at sea.
(4) Speaks and writes ——.
(5) Speaks ——.
(6) Physical condition.
Fitness for war service.
(7) Personal and financial situation.
(8) Attributes of mind, of character.
Temperament and intellectual faculties.
(9) Professional and service knowledge.
Scientific attainments.
(10) Conduct towards superiors and inferiors.
(11) Judgment (appreciation of value) of subordinates.
(12) Influence over officers and men.
Care of same.
(13) Zeal and success.
(14) Qualifications for command of a fleet or division; what efficiency displayed in military, nautical, and tactical matters.
(15) Whether fitted for special missions in foreign waters in command of a squadron.
(16) Services rendered while in high administrative or technical commands.
(17) Performances in military and nautical scientific fields.
Literary works.
General impression.
(18) If fulfills well present duties and is fitted for higher ones.

These Chief Reports are accompanied by a Service Register which is a short history of the official life of the subject of the report, containing also his place of birth, religion, whether married or single, father of how many children, marriage portion of wife, private means of support, etc.

Qualification Lists are made out by the immediate superiors or commanding officers of the persons concerned, or if the latter are serving under several officers, then by a Board composed of such officers.

These Lists must go through the regular official channels and be indorsed by the senior authorities through whose hands official documents pass.

The Regulations contain elaborate tables for every possibly duty, showing what persons should make, indorse, and forward all Qualification Lists.

These Lists are sent to the Marine Section at the end of each year, the forwarding officer adding any remarks he may think proper.

Any officer may see his Qualification List of the preceding year.

Deficiencies are communicated to all delinquents accompanied by a warning.

QUALIFICATION LIST FOR OFFICERS UP TO AND INCLUDING GRADE OF LIEUTENANT, FIRST CLASS.

Name.
Rank.

(Divided into quarters.)

(1) Year 18——
(2) Period, first quarter, second quarter, third quarter, fourth quarter.
(3) Employment.
Aptitude and ability in—
(4) Seamanship.
(5) Gunnery.
(6) Navigation.
(7) Other professional matters.
(8) Can be intrusted with the deck under all circumstances with perfect confidence.
(9) Knowledge of administrative matters.
(10) Knowledge of languages.
(11) Zeal, success, effort towards higher education.
Conduct—
(12) Before the enemy.
(13) On duty.
(14) Off duty.
(15) Physical condition.
(16) Peculiarities of character, intellect, and disposition.
(17) Remarks.
(18) Qualification for promotion.

Signed by commanding officer and executive officer and forwarded by admiral.

QUALIFICATION LIST FOR LIEUTENANT-COMMANDERS, COMMANDERS, AND CAPTAINS.

Name.
Rank.

(Divided into quarters.)

(1) Year.
(2) Period.
(3) Employment.
(4) Professional attainments and skill.
(5) Knowledge of languages.
(6) Zeal, success, and efforts towards higher education.
(7) Qualification for command of vessels or squadrons.
(8) Same for high administrative positions.
Conduct—
(9) Before the enemy.
(10) On duty.
(11) Off duty.
(12) Physical condition.
(13) Peculiarities of character, intellect, and disposition.
(14) Remarks.
(15) Qualification for promotion.

In these Lists, "conduct" must have remarks concerning personal courage, determination, coolness, perseverance, etc. In case of no war experience the conduct shall be given with regard to subordination, loyalty, faithfulness on duty, whether on duty too severe or too slack, is inclined to prejudice or favoritism, whether carries out regulations and enforces discipline, understands management of men and possesses faculty of improving those under him; finally, if he shows for his subordinates a special solicitude by which he can gain their confidence and loyalty.

Off duty refers to conduct with superiors and inferiors, whether socially or misanthropically inclined, and what kind of society he affects.

"Physical condition" means general condition, fitness for sea or other duty, quick or slow eye, if endures hardships of sea life or if better qualified for other duty.

"Peculiarities of character, intellect, and disposition" must show vivacity, quickness of thought, correctness of judgment, inclination to prejudice, strength of memory, and above all any peculiarity whose description will give a correct estimate of the man's value.

Under "character" come temper, frankness, firmness, energy, determination, or any other marked attribute.

"Remarks." Here is added any other information tending to depict the officer as he is in reality, whether any special duty has been confided to him and how it has been executed, together with any deficiencies he may possess.

"Qualifications for promotion" must conclude in the following terms; "Preëminently qualified," when distinguished by particular excellence and attainments which justify the belief that he is unusually well fitted to perform the duties of the next higher grade.

"Qualified," when physically, mentally, and morally fit for promotion.

"At present not qualified," with reason for same and whether he should lose numbers.

"Not qualified," with note whether he is fit for shore duty.

In the qualification lists for lieutenants, first-class, lieutenant-commanders, and commanders, great attention is paid to knowledge of every description, by which an officer in improving himself brings credit on the service, while notes are made of all excellence in manœuvring ships, acquaintance with all means of offense and defense, all new appliances, tactics, seamanship, administrative ability, etc.

It is very evident that the system of reports above described keeps the Austrian Navy Department well informed about its officers. Of course it may occur that some reports are unjust, in spite of the stringent warning in the regulations on this point, but the fact that the reports are sent in periodically and continuously will enable a very good average to be struck at headquarters.

Every officer of merit or ambition has the satisfaction of knowing that good service either afloat or ashore will redound to his credit and that, however far from headquarters such service may have been given, the knowledge of his efforts and efficiency will not remain limited to the few individuals immediately about him, but will be permanently shown in his department record.

Every officer realizes that his future career depends upon himself alone, and that if he is satisfied to merely fulfill his duties in a perfunctory manner he can not hope for promotion.

It would seem to be almost impossible that with such a system an unworthy officer could be promoted, and as a matter of fact the Austrian officers are an able, efficient, hard-working body of men, endowed with a high degree of *esprit de corps.*

There is no regular retiring age, but any officer after 40 years' service can claim retirement. In computing these 40 years, war service counts as double time.

All officers who have 10 years' service or over have a right to retirement for disability, as also have those who have reached 60 years of age, this being voluntary and not compulsory.

The effect of a combination of such retirement laws with promotion by seniority alone is shown in the following table:

Grade.	Age of senior.	Age of junior.	Average time in grade.
Admiral	62	....	....
Vice-admiral	62	58	8
Rear-admiral	58	54	3
Captain	54	50	4
Commander	49	47	5
Lieutenant-commander	50	44	4
Lieutenant, first class	47	33	22
Lieutenant, second class	35	31	3
Sublieutenant	33	23	7
Cadet	23	21	3

It will be noticed that the French and Italian systems of promotion are very similar; also that the English and Austrian differ widely from them and from each other, but that one feature is common to all, viz: An officer's qualification for promotion to the next higher grade is determined, not by an examination of his condition at any one time, but is the result of observations of his entire previous career.

Age of the officer at the $\left\{\begin{matrix}\textit{head}\\ \textit{foot}\end{matrix}\right\}$ *of the list.*

	England.	France.	Russia.	Italy.	Germany.	Austria.	United States.
Vice-admiral	59	59	79	63	52½	62	....
	57	55	56	54	49½	58	....
Rear-admiral	58	56	60	56½	48	58	61
	55	59	42	53	45	54	59
Commodore	....	....	....	....	....	....	58
	....	....	....	....	....	....	57
Captain	51	57	54	51	43	54	56½
	42½	49	42	46	42	50	50
Commander	47	56	30	46	41½	49	49½
	36½	43	36	43	38	47	46
Lieutenant-commander	....	....	....	44	38	50	46½
	....	....	....	41	33½	44	45
Lieutenant	44½	46	44	43	32	47	45
	23	27	27	25½	24½	31	32½
Sub-lieutenant or ensign	23	27½	33	25	24	33	33
	19½	22	18	20	22	23	22

The foregoing figures are obtained, in nearly every case, by averaging the ages of the five officers at the head and foot of the lists, taking a smaller number for flag officers.

For the German Navy the exact ages of the officers could not be obtained, and the figures in the table are computed in the following manner: By taking the average length of service of the officers at the head and foot of the lists and adding thereto, fifteen for vice-admirals, rear-admirals, and senior captains; sixteen for junior captains, commanders, and senior lieutenant-commanders; seventeen for junior lieutenant-commanders, lieutenants, and senior sublieutenants; eighteen for junior sublieutenants; these figures being the average age of entry at the time those officers entered the service.

It will be noticed that the German corps of officers is young, and this in spite of the fact that promotion is strictly by seniority, and that there is no forced retirement in grade. This is owing partly to the exceedingly rigid system of exclusion, which removes any officer from the active list who shows the least inability or even disinclination to keep up with his profession, and partly to the fact that the German Navy is young, being virtually but twenty years in existence, so that the number of officers has been, and is still being, increased with the number of ships. Promotion, however, is now much slower than it was some five or six years ago; and the ages from senior lieutenant to junior commander included, show a decided increase.

For purposes of comparison it must be remembered that in the English, French, and Russian Navies there is no grade between lieutenant and commander.

For the United States Navy the grade of junior lieutenant has been considered as part of the grade of lieutenant.

XI.

SOME STANDARD BOOKS ON PROFESSIONAL SUBJECTS.

List prepared by Lieut. G. W. Mentz, U. S. Navy.

Officers and others are requested to inform the Office of Naval Intelligence of any standard works on professional subjects, of recent date, which are not mentioned in the following list.

Foreign books, newspapers, and periodicals may be obtained from B. F. Stevens, 4 Trafalgar Square, Charing Cross, London. From B. F. Stevens' advertising circular "new books are charged at trade prices, which are usually 25 per cent off the price of publication." "Book postage to America is only one-half penny for every two ounces up to four pounds weight."

"The discount off publication price is about equivalent to the cost of freight or postage, and commission; hence, in making purchases of new books it is safe to estimate that the books would be received at a cost of 25 cents to the shilling (publication price), exclusive of duty, if any."

Remittances to B. F. Stevens, 4 Trafalgar Square, Charing Cross, London, may be made in sterling by banker's drafts, or post-office orders on London, or in American currency at $5 to the pound sterling, this being 25 cents to the shilling. For odd amounts send postage stamps. New York agents, Tice & Lynch, 45 William street.

AMMUNITION.

Treatise on Ammunition, 1887. Printed by order of the Secretary of State for War. Price 6s. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., London; or Adam & Charles Black, North Bridge, Edinburgh; or Hodges, Figgis & Co., 104 Grafton street, Dublin. Fourth edition, corrected to January 1, 1887.

ARMOR.

Development of Armor for Naval Use. By Lieut. E. W. Very, U. S. Navy. Published in the proceedings of the U. S. Naval Institute, Vol. IX, No. 3; Whole No. 25: 1883. Can be purchased of the Secretary of the U. S. Naval Institute, Annapolis, Md. Price $1.

ARMOR AND ITS ATTACK BY ARTILLERY. By Charles Orde Browne, Captain late Royal Artillery, Lecturer on Armor to the Royal Artillery College, Woolwich. Printed by Royal Artillery Institution. Published by Messrs. Dulau & Co., 37 Soho Square, London, W. C., 1887. Book brings the subject up to that date.

The two above works and Chapter VI, of General Information, Series No. X, by Lieutenant Southerland, U. S. N., contain a complete history of the Development of Armor.

THE PRESENT POSITION OF BRITISH AND FOREIGN ARMOR. By Capt. C. Orde Browne, late R. A. (Lecturer on Armor to the Royal Artillery College. Published in the United Service Magazine, February, 1891. Page 464 *et seq.* Price 1*s.* Offices of Magazine, 15 York street, Covent Garden, W. C., London.

NOTES ON ARMOR AND ARMOR TRIALS are contained in the General Information Series of the Office of Naval Intelligence, beginning with the year 1886 and continuing in successive numbers.

General Information Series No. V, 1886, page 239 *et seq.* Edition exhausted.

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General Information Series No. VIII, 1889, Distribution of Armor, pages 81 to 135, give a graphic history of armor protection and distribution on war vessels. Pages 424 to 427. Notes on armor.

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These numbers have been furnished to ships' libraries as well as to the officers of the Navy.

COMPASSES.

ADMIRALTY MANUAL FOR THE DEVIATIONS OF THE COMPASS. By F. J. Evans, R. N., F. R. S., superintendent of the Compass Department of the Admiralty, and Archibald Smith, M. A., F. R. S., late Fellow of Trinity College, Cambridge. Fifth edition. Published by order of the Lords Commissioners of the Admiralty. London, 1882. Sold by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Price 4*s.* 6*d.* Supplied to U. S. naval ships' libraries. Text-book at Naval Academy; may be obtained from storekeeper. Price $1.60.

ELEMENTARY MANUAL FOR THE DEVIATIONS OF THE COMPASS IN IRON SHIPS. Arranged in a series of questions and answers, intended for the use of seamen, adjusters of compasses, and navigation schools, and as an introduction and companion to the Admiralty Manual for the Deviations of the Compass. By F. J. Evans, K. C. B., F. R. S., Captain, R. N. Seventh edition. Revised and with an appendix by E. W. Creak, Staff Commander, R. N., F. R. S. Published by J. D. Porter, London, 1889, 31 Poultry and 11 King street, Tower Hill. Price $1. May be obtained from storekeeper at Naval Academy. Price $1.60. Text book at Naval Academy.

FINDING THE ERROR OF THE MARINE COMPASS ON BOARD SHIP. By B. F. Greene, Professor of Mathematics, U. S. Navy, Superintendent of Compasses, Bureau of Navigation, Navy Department. Printed by Government Printing Office. 1875. Supplied to U. S. ships' libraries. Price $2.50.

THE MATHEMATICAL THEORY OF THE DEVIATIONS OF THE COMPASS. Arranged the use of the cadets at the U. S. Naval Academy. By J. A. Howell, C mander, U S. Navy. Printed by the Government Printing Office, 1879, W ington, D. C.

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Practical Guide for Compensation of Compass without Bearings. By Lieutenant Collet, French navy, tutor in the Polytechnic School of France. Translated by W. Bottomley, with a preface by Sir William Thomson, LL. D., etc., professor of natural philosophy in the University of Glasgow, etc. Price 3*s.* 6*d.* Griffin & Co., 2, The Hard, Portsmouth, England.

CHRONOMETERS.

Notes on the Management of Chronometers and the Measurement of Meridian Distances. By Charles F. N. Shadwell, esq., C. B., Captain R. N. New edition carefully revised. London: J. D. Potter, 31 Poultry and 11 King street, Tower Hill.

La marche et la conduite des chronometres, apres les travaux de MM. Caspari Lieussou, de Magnae, etc. Par Fulgence Legal, lieutenant de vaisseau. Paris: Berger-Levrault et Cie., 5 Rue des Beaux-Arts. 1882. Price 1 franc 50 centimes.

Navy Scientific Papers, No. 6. Chronometer Rates as Affected by Change of Temperature and Other Causes. By Lieut. Commander C. H. Davis, jr., U. S. Navy, in charge of chronometers at the Naval Observatory, Bureau of Navigation, Navy Department. Washington: Government Printing Office. 1877. May be obtained by Naval Officers, from the Bureau of Equipment. Published also as an appendix to Washington Observations.

ELECTRICITY AND MAGNETISM.

Practical Electricity: A laboratory and lecture course for first-year students of electrical engineering, based on the practical definitions of the electrical units. By W. E. Ayrton, F. R. S., associate member of the Institution of Civil Engineers; Professor of Applied Physics at the City and Guilds of London Central Institution. With numerous illustrations. Fourth edition. Cassel & Company, limited, London, Paris, New York, and Melbourne. 1889. Also by W. J. Johnston Company, Times Building, New York. Price, $2.50.

Dynamo-Electrical Machinery: A manual for students of electro-technics. By Silvanus B. Thompson, D. Sc., B. A., Principal of, and Professor of Physics in, the City and Guilds of London Technical College, Finsbury; late professor of experimental physics in University College, Bristol; member of the Society of Telegraph Engineers and Electricians; member of the Physical Society of London; *membre de la Société de Physique de Paris;* honorary member of the Physical Society of Frankfort-on-the-Main; fellow of the Royal Astronomical Society. Third edition, enlarged and revised. E. & F. N. Spon, 125 Strand, London; 12 Cortlandt street, New York. 1888. Griffin & Co., 2, The Hard, Portsmouth, England. 12*s.* 6*d.*

ELEMENTARY MANUAL OF MAGNETISM AND ELECTRICITY: Specially arranged for the use of first-year science and art department and other electrical students. By Andrew Jamieson, M. Inst. C. E.; professor of engineering, The Glasgow and West of Scotland Technical College, etc. Part I, Magnetism. Part II, Voltaic electricity, electro-magnetism, and electro-kinetics. Part III, Electrostatics or frictional electricity. 1889 and 1890. Numerous illustrated experiments. Charles Griffin & Co., Exeter street, Strand, London.

ELECTROMOTORS, HOW MADE AND HOW USED: A handbook for amateurs and practical men. Price, $1.20. By S. R. Bottone. New York: D. Van Nostrand & Co.

The following works, published and for sale by the W. J. Johnston Company, limited, 167–177 Times Building, New York:

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MURDOCK, J. B. NOTES ON ELECTRICITY AND MAGNETISM. Designed as a companion to S. P. Thompson's Elementary Lessons. Cloth. 139 pages. 38 illustrations. Price 60 cents. Also published by Macmillan & Co., New York. 1881. (Proceedings of U. S. Naval Institute).

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Reprint of Papers on Electrostatics and Magnetism. By Sir William Thompson, D. C. L., Professor of Natural Philosophy at the University at Glasgow. Second edition. 1884. London: Macmillan & Co.

Electricity in Theory and Practice, or the Elements of Electrical Engineering. By Lieut. Bradley A. Fiske, U. S. Navy. Cl., 270 pages. 180 illustrations. Price, $2.50. The W. J. Johnston Co. limited, 167–177 Times Building, New York. Also by D. Van Nostrand, 23 Murray street and 27 Warren street, New York. Griffin and Co., 2, The Hard, Portsmouth, England. Price, 10s.

L'Électricité appliquée à l'art militaire. Par le Colonel Gun. Avec 140 figures dans le texte. Paris, librairie J.-B. Baillière et fils, rue Hautefeuille, 19, près du boulevard Saint-Germain, 1889. Price, 3 francs 50 centimes.

L'Éclairage électrique à la guerre. Par Rodolphe Van Wetter, lieutenant d'artillerie de l'armée belge. Gravures dans le texte et atlas de dix-sept planches. Prix, 7 francs 50 centimes. Paris, G. Carre, libraire-éditeur, rue Saint André des Arts, 58. Madrid, Fuentes y Capdeville, 7 Plaza de Santa Anna. Rome, Turin, Florence, H. Loescher, libraire-éditeur, 1889.

Electricité expérimentale et pratique. Cours professé à 'Ecole des torpilleurs, par H. Leblond, agrégé des sciences physiques (Bibliothèque du marin). 3 volumes in-8°, avec figures et planches, broché, chacun à 6 francs.

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Vol. II. Mesures électriques, 1889.

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Leçons sur l'Électricité, professées à l'Institu Étlectrotechnique Montefiore, annexé à l'Université de Liège. Gérard (Eric), directeur de l'Institut électrotechnique Montefiore. Deux volumes grand in-8, se vendent séparément:

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Tome II. Canalisation et distribution de l'énergie électrique. Applications de l'électricité à la production et à la transmission de la puissance motrice, à la traction, à la l'éclairage et à la métallurgie. Grand in-8, avec 42 fig. dans le texte; 1890. Prix, 8 francs.

Published by Gauthier-Villars et fils, 55, Quai des Grands-Augustins, Paris.

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Service Chemistry. Being a short manual of chemistry and its application to the naval and military services. By Vivian B. Lewes, F. I. C., F. C. S., professor of chemistry, Royal Naval College, Greenwich; associate of the Institution of Naval Architects, etc., illustrated. Published in London by W. B. Wittingham & Co., 91 Gracechurch street, and 44 and 45 Charterhouse Square, E. C., 1889. Chapters XIV to XVI, inclusive, devoted to explosives.

Traité théorique et pratique des explosifs modernes et Dictionnaire des poudres et explosifs. By Paul F. Chalon, ingénieur des arts et manufactures. Seconde édition. Paris, 1889. Publishers, E. Bernard et Cie, 71, rue La Condamine; 53, Quai des Grands-Augustins. 1 vol. in-8 de 506 pp., avec 162 fig. dans le texte. Price, 25 francs.

Researches on Explosives, Fired Gunpowder. By Captain Noble (late R. A.), F. R. S., etc., and F. A. Abel, C. B., F. R. S., etc. Published by the United States Artillery School Press, 1888.

Submarine Mines and Torpedoes as applied to Harbor Defense. By John Townsend Bucknil, London, Offices of Engineering, 35 and 36 Bedford street, 1889. [See under Submarine Mines.] Chapter VI of this work, under the title of "Examination of the Different Explosives," gives short descriptions of the principal ones as far as known up to date, 1889, their composition, intensity, advantages for submarine mines, etc.

A Handbook on Modern Explosives. By M. Eissler, mining engineer and metallurgical chemist, author of Modern High Explosives, etc. Published by Crosby Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill, 1890. This is a practical treatise on the manufacture and application of dynamite, guncotton, nitroglycerine and other explosive compounds, including the manufacture of collodion cotton.

High Explosives in Warfare. By Commander F. M. Barber, U. S. Navy. A lecture delivered November 28, 1890, before the Franklin Institute. Published in The Journal of the Franklin Institute, vol. CXXXI, No. 782, February, 1891, No. 2, pages 117 *et seq.*, Philadelphia. Dr. Wm. H. Wahl, secretary of the institute.

Handbook of Gunpowder and Gun Cotton. By Maj.-Gen. W. H. Wardell, late Royal Artillery, 1888. Printed by order of the Secretary of State for War. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C., or Adam & Chas. Black, North Bridge, Edinburgh, or Hodges, Figgins & Co., 104 Grafton street, Dublin. Price 2*s.* 6*d.*

Professional Papers of the Corps of Engineers, U. S. Army. No. 23. Report upon Experiments and Investigations to Develop a System of Submarine Mines for Defending the Harbors of the United States. Submitted to the Board of Engineers by Lieut. Col. Henry L. Abbott, Co of Engineers, Brevet Brigadier General, U. S. Army, Member of the Boa Washington, Government Printing Office, 1881.

A Dictionary of Explosives. By Maj. J. P. Cundill, Royal Artillery. 1889. Print by W. & J. Mackay & Co., Chatham. Published by the Royal Engine Institute, Chatham. Agents, W. & J. Mackay & Co., Chatham, Kent. A sold by Hamilton, Adams & Co., London.

Mémorial des Poudres et Salpêtres, publié par les soins du service des poudres et salpêtres avec l'autorisation du ministre de la guerre. Grand in-8, trimestriel.

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A Treatise on Hygiene and Public Health. Edited by Albert H. Buck, M. D., Instructor in Otology in the College of Physicians and Surgeons, New York, etc. Two volumes. New York, William Wood & Co., 1879.

Traité d'Hygiène Navale, par J.-B. Fonssagrives, médecin en chef de la marine, en retraite, professeur à la Faculté de Montpellier, etc., etc. Deuxième édition. 145 figures intercaleés dans le texte. Paris, J.-B. Baillière et fils, 19, Rue Hauteville, Paris, 1877; Tindall & Cox, King William's street, London.

Traité d'Hygiène Militaire, par G. Morache, médecin-major de première classe, professeur agrégé à l'École d'application de médecine et de pharmacie militaire. Paris, 1874, J.-B. Baillière et fils, 19, Rue Hauteville.

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INTERNATIONAL LAW.

Introduction to the Study of International Law. Designed as an aid in teaching and in historical studies. By Theodore D. Woolsey. Sixth edition, revised and enlarged by Theo. S. Woolsey. Published by Charles Scribner's Sons, 1891. Text-book at the U. S. Military Academy. Price $2.50.

Military Law. By Lieut. Col. W. Winthrop, Deputy Judge-Advocate-General of the U. S. Army; author of the Annotated Opinions of the Judges-Advocate-General. Two volumes. Published by W. H. Morrison, law bookseller and publisher, Washington, D. C., 1886. Text book at the U. S. Military Academy.

A Treatise on the Constitutional Limitations which rest upon the Legislative Power of the States of the American Union. By Thomas M. Cooley, LL. D., one of the justices of the supreme court of Michigan, and Jay professor of law in the University of Michigan. Fifth edition, with considerable additions giving the results of the recent cases. Published by Little, Brown & Co., 1883.

Treaties and Conventions concluded between the United States of America and other Powers since July 4, 1776, containing notes with references to negotiations preceding the several treaties, to the executive, legislative, or judicial construction of them, and to the causes of the abrogation of some of them; a chronological list of treaties; and an analytical index. Compiled by John H. Haswell Chief of the Bureau of Indexes and Archives of the Department of State, Washington: Government Printing Office, 1889. May be obtained by applying to Department of State.

The Constitution of the United States, defined and carefully annotated, with an appendix, supplement, and index thereto. By George W. Paschal, LL. D., author of Paschal's Annotated Digest, a Treatise on Charitable Uses, Digest of Decisions, etc. Washington, D. C.: William H. Morrison, publisher, importer, and stationer, 1882. Price $3.

Elements of International Law. By Henry Wheaton, LL. D., Minister of the United States at the Court of Prussia; corresponding member of the Academy of Moral and Political Sciences in the Institute of France; honorary member of the Royal Academy of Sciences at Berlin, etc. Second English edition, edited with notes and an appendix of statutes and treaties bringing the work down to the present time. By A. C. Boyd, esq., LL. D. (Camb.), J. P., barrister at law, of the Inner Temple, and midland circuit, author of the "Merchant Shipping Laws." London: Stevens & Sons, 119 Chancery Lane, law publishers and bookseller, 1880.

Manual of International Law for the use of Navies, Colonies, and Consulates. By Jan Helenus Ferguson, Minister of the Netherlands in China; formerly of the Netherlands Royal Navy and Colonial Service. Two volumes. London: W. B. Whittingham & Co., 91 Gracechurch street, 1884. Also by Martinus Nyhoff, The Hague; and Noronha & Co., Hongkong.

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Declaration of War; a Survey of the Position of Belligerents and Neutrals with relative considerations of Shipping and Marine Insurance during War. By Douglas Owen, of the Inner Temple, barrister at law, secretary of the Alliance Marine Assurance Company, limited, and the Association of Average Adjusters of Great Britain. Author of Marine Insurance Notes and Clauses. London, Stevens & Sons, limited, law publishers and booksellers, 119 and 120 Chancery Lane, 1889.

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A Treatise upon the Law of Extradition. With the conventions upon the subject existing between England and foreign nations, and the cases decided thereon. By Sir Edward Clarke, Knt., Her Majesty's solicitor-general, formerly Tancred student of Lincoln's Inn. Third edition. London, Stevens & Haynes, law publishers, Bell Yard, Temple Bar, 1888.

International Law, with Materials for a Code of International Law. By Leone Levi, F. S. A., F. S. S., of Lincoln's Inn, barrister at law, professor of commercial law in King's College, London, doctor of political economy of the University of Tubingen, etc. International Scientific Series, published by
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Nouveau Droit International Public, suivant les besoins de la civilisation m
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docteur en droit, juge d'instruction près le tribunal de Péronne. Deu
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Le Droit International Théorique et Pratique, précédé d'un exposé historique des progrès de la science du droit des gens. Par M. Charles Calvo, ancien ministre, membre correspondant de l'Académie des sciences morales et politiques de l'Institut de France, de l'Académie royale d'histoire de Madrid, membre fondateur de l'Institut du droit international, etc. Troisième édition complète. Four volumes. Paris, Guillemin et Cie., éditeurs, 14, Rue Richelieu; E. Thorn, éditeur, 7, Rue Médicis; G. Pedone Lauriel, éditeur, 13, Rue Soufflot; A. Rousseau, éditeur, 14, Rue Soufflot, 1881.

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An Introduction to the Constitutional Law of the United States, especially designed for students, general and professional. By John Norton Pomeroy, LL.D., author of Lectures on International Law in Time of Peace. Tenth edition, revised and enlarged, by Edmund H. Bennett, LL.D., Dean of the Boston University Law School. Boston and New York: Houghton, Mifflin & Co., the Riverside Press, Cambridge. 1888.

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Commentaries upon International Law. By Sir Robert Phillimore, D. C. L., member of Her Majesty's most honorable privy council and judge of the high court of admiralty. Four volumes: Vol. I, 1879, third edition; Vol. II, 1882, third edition; and Vol. III, 1885, third edition; Vol. IV, 1874, second edition.

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The Law and Practice of United States Courts-Martial. By A. A. Harwood, U. S. Navy. New York: D. Van Nostrand, 192 Broadway. 1867.

Order of Procedure in Naval General Courts-Martial, compiled from various orders, regulations, and instructions, which have been issued from time to time from the Navy Department and from other sources, for the convenience of novitiating judge-advocates. By M'Lane Tilton, United States Marine Corps. Washington: Printed by Powell & Ginck. 1874. Contains also order of procedure for naval summary courts-martial and naval courts of inquiry.

Naval Summary Courts-Martial, compiled and arranged by Lieut. S. C. Lemly, U. S. Navy, and Lieut. F. L. Denny, U. S. Marine Corps, February 1, 1891. Price 50 cents. Published by the Army and Navy Register Publishing Company, 1420 Pennsylvania avenue, Washington, D. C.

The Principles of the Law of Evidence, with Elemenary Rules for Conducting Examination and Cross-Examination of Witnesses. By W. M. Best, A. M., LL. B. American edition (from seventh English edition). By Charles F. Chamberlayne, of the Boston Bar. Boston: Soule & Bugbee, law publishers, 37 Court street. 1883. Used at Harvard Law School.

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MACHINERY.

ENGINES, BOILERS, FUEL, ETC.

Marine Propellers. By Sir Sidney W. Barnaby, M. I. N. A., and Assoc. M. Inst. C. E., gold medallist of the Institution of Civil Engineers. Being a course of three lectures delivered at the Royal Naval College, Greenwich, March, 1885. E. and F. N. Spon, 125, Strand, London. New York: 35 Murray street. 1885.

A Manual of Marine Engineering; comprising the designing, constructing, and working of marine machinery. By A. E. Seaton, lecturer on marine engineering to the Royal Naval College, Greenwich, etc.; with numerous tables and illustrations reduced from working drawings. Sixth edition. London: Charles Griffin & Co., 2 The Hard, Portsmouth, England. 1886. Price 18*s*.

The Marine Steam Engine; a treatise for the use of engineering students and officers of the Royal Navy. By Richard Sennett, Chief Engineer Royal Navy, etc., and late instructor in marine engineering at the Royal Naval College. With numerous diagrams. London: Longmans, Green & Co. 1885. Also Griffin & Co., 2 The Hard, Portsmouth, England. Price 21*s*. Text Book Naval Academy. May be purchased from the storekeeper N. A. Price $5.62.

A Manual of the Steam Engine and other Prime Movers. By William John Macquorn Rankine, civil engineer, etc.; late regius professor of civil engineering and mechanics in the University of Glasgow, etc.; with numerous engravings, folding plate, and a diagram of the mechanical properties of steam. Third edition, revised by W. J. Miller, C. E., secretary Inst. Engineers and Shipbuilders in Scotland. London: Charles Griffin & Co., Exeter street, Strand. 1882. Griffin & Co., 2 The Hard, Portsmouth, England. Price, 12*s*. 6*d*.

A Treatise on Steam Boilers; their Strength, Construction, and Economical Working. By Robert Wilson, C. E., late inspector for the Manchester Steam Users' Association for the prevention of steam-boiler explosions and for the attainment of economy in the application of steam. Fifth edition. London: Crosby, Lockwood & Co., 7 Stationers' Hall Court, Ludgate Hill. 1879.

A Manual of Rules, Tables, and Data for Mechanical Engineers. Based on the most recent investigations; of constant use in calculations and estimates relating to strength of materials and of elementary constructions, labor, heat an its applications, steam and its properties, combustion and fuels, steam boiler steam engines, gas engines, flow of air and of water, air machines, hydrauli machines, mill gearing, friction and the resistance of machinery, etc., weight measures, and moneys, British and foreign, with the reciprocal equivalen for the conversion of British and French compound units of weights, pre sure, time, space, and money, etc. By Daniel Kinnean Clarke, member o the Institution of Civil Engineers. Second edition. London: Blackie & So Paternoster Buildings. 1878.

STEAM BOILER EXPLOSIONS, IN THEORY AND IN PRACTICE. By R. H. Thurston, A. M., Doc. Eng. Director of the Sibley College, Cornell University. Author of a History of the Steam Engine; Stationary Steam Engines; Materials of Engineering, etc. Well illustrated. New York, John Wiley & Sons. 1887.

A TEXT BOOK ON STEAM AND STEAM ENGINES. Specially arranged for the use of science and art, City and Guilds of London Institute, and other engineering students. By Andrew Jamieson, principal and professor of engineering, College of Science and Arts, Glasgow; member of the Society of Telegraphic Engineers and Electricians; member of the Institute of Civil Engineers; fellow of the Royal Society, Edinburgh; joint author of Electrical Rules, Tables, and Formulæ. Second edition. With numerous diagrams, four folding plates, and examination questions. London: Charles Griffin & Co., Exeter street, Strand. 1887.

TRIPLE EXPANSION ENGINES AND ENGINE TRIALS. By Prof. Osborne Reynolds, LL. D., F. R. S., M. Inst. C. E. With an abstract upon the discussion of the paper. Edited by F. E. Idell, M. E. New York: D. Van Nostrand Company, 23 Murray street, and 27 Warren street. 1890.

ELEMENTARY MECHANISM: A text book for students of mechanical engineering. By Arthur T. Woods, assistant engineer, U. S. Navy, member of the South American Society of Mechanical Engineers; assistant professor of mechanical engineering, Illinois State University, Champaign, Ill., and Albert W. Stahl, assistant engineer, U. S. Navy, member of the American Society of Mechanical Engineers; professor of mechanical engineering, Purdue University, La Fayette, Ind. New York: D. Van Nostrand, publishers 23 Mutray street.

ON THE ELEMENTARY RELATION BETWEEN PITCH, SLIP, AND PROPULSIVE EFFICIENCY. By W. Froude, Esq., M. A., F. R. S. Read at the nineteenth session of the Institution of Naval Architects, April 11, 1878. Published in "Transactions of the Institution of Naval Architects," which are sold by Henry Sothern & Co., 36 Piccadilly, London, W.

ON THE MINIMUM AREA OF BLADE IN A SCREW PROPELLER NECESSARY TO FORM A COMPLETE COLUMN. By James H. Cotterill, M. A., F. R. S. Read at the nineteenth session of the Institution of Naval Architects, April 11, 1878. Published in "Transactions of the Institution of Naval Architects, which are sold by Henry Sothern & Co., 36 Piccadilly, London, W.

BOILERS, MARINE AND LAND: THEIR CONSTRUCTION AND STRENGTH. A Handbook of Rules, Formulæ, Tables, etc., relative to Material, Scantlings, and Pressures, Safety Valves, Springs, Fittings, and Mountings, etc., for the use of Engineers, Surveyors, Draughtsmen, Boiler-Makers, and Steam Users. By Thomas W. Traill, F. E. R. N., Member of the Institute of Civil Engineers, Engineer-in-Chief to the Board of Trade, etc. Second Edition. With Illustrations. London: Charles Griffin & Co., Exeter Strand. 1890.

THERMODYNAMICS OF THE STEAM ENGINE AND OTHER HEAT ENGINES. By Cecil H. Peabody, Associate Professor of Steam Engineering, Massachusetts Institute of Technology. New York: John Wiley & Sons, 15 Astor Place. 1889.

THE STEAM ENGINE CONSIDERED AS A THERMODYNAMIC MACHINE: A Treatise on the Thermodynamic Efficiency of Steam Engines; illustrated by Diagrams, Tables, and Examples from Practice. By James H. Cotterill, M. A., F. R. S., Professor of Applied Mechanics in the Royal Naval College. Second Edition. Revised and Enlarged. F. & E. & F. N. Spon, 125 Strand, London. New York: 12 Courtland street. 1890.

A MANUAL OF STEAM BOILERS: THEIR DESIGN, CONSTRUCTION, AND OPERATION. For Technical Schools and Engineers. By R. H. Thurston, M. A., Doc. Eng.; Director of Sibley College, Cornell University; Past President American Society of Mechanical Engineers, etc. New York: John Wiley & Sons, Astor Place. 1888.

Tables of the Properties of Saturated Steam and other Vapors. By Cecil H. Peabody, B. S., assistant professor of steam engineering in the Massachusetts Institute of Technology. New York; John Wiley & Sons. 1888.

Nouvelles machines marines des bâtiments à grand vitesse; des torpilleurs et des embarcations à vapeur. Par Maurice Demoulin, ingénieur des arts et manufactures. Vol. i, text; Vol. ii, plates. Paris, E. Bernard et Cie., Quai des Grands-Augustins, 53. Price 40 francs.

Les Machines Marines, Cours Professé à l'École d'application du génie Maritime. A. F. A. Bienaymé, directeur de l'École d'application du génie maritime. Ouvrage courronné par l'Académie des sciences.

Première partie: Historique et description d'ensemble.
Deuxiéme partie: Considérations théoriques relatives à l'emploi de la vapeur.
Troisième partie: Cylindres, tiroirs, régulation, détentes.
Quatrième partie: Condensation, alimentation, transmission de mouvement.
Cinquième partie: Propulseurs, chaudières.

L'ensemble de l'ouvrage comprend un volume de texte grand in-4° de 500 pages et un atlas de 162 planches doubles. Price of book complete, 60 francs. Published by E. Bernard & Cie., 53, Quai des Grands-Augustins, Paris.

Supplément aux Cours du Borda et de l'École d'application. Machines auxiliaires en usage sur les bâtiments de la flotte. Par P. Guillaume, mécanicien en chef de la marine. Ouvrage accompagné d'un atlas in-folio de 59 planches gravées. Paris, Challamel âiné, éditeur, Librairie maritime et coloniale, 5, Rue Jacob et Rue Furstenberg, 2, 1887. Also published by E. Bernard et Cie., 53, Quai des Grands-Augustins, Paris. Price, book complete, 33 francs.

Valve gears. By H. W. Spangler, New York: John Wiley & Sons.

Fuels; Solid, Liquid, and Gaseous. Their analysis and valuation for the use of chemists and engineers. Lockwood & Sons, London, 1891, 7 Stationers' Hall Court, Ludgate Hill. By H. J. Phillips, F. C. S., analytical and consulting chemist to the Great Eastern Railway, etc.

Guide pratique du chauffeur et du mécanicien sur les bateaux torpilleurs, rédigé en conformité de la dépêche ministérielle du 15 janiver 1887, par M. E. Clergeay, mécanicien en chef de la marine. Dessins du 2^e maître-mécanicien. C. Degny, Paris, 1888, un beau vol., in-8, relié. Price 5 francs 50 centimes.

Steam Boiler Construction. A Practical Handbook for Engineers, Boiler-makers, and Steam-users, containing a large collection of Rules and Data relating to recent practice in the Design, Construction, and Working of all kinds of Stationary, Locomotive, and Marine Steam-Boilers. By Walter S. Hutton, Civil and Mechanical Engineer. Three hundred illustrations. London: Crosby Lockwood & Son, 7 Stationers' Hall Court, Ludgate Hill. 1891.

Boiler Tests. By Geo. H. Barrus. This book gives the results of a large number of tests made by Mr. Barrus, whose reputation as an expert in the line of engine and boiler tests, is a sufficient assurance that the work is of great value and interest to every owner of a boiler and user of steam. The work, covers nearly 150 practical working tests, and the results are compared so as to show in the clearest possible manner the performance of the different kinds of boilers and fuels tested. Boston: Gowing & Company, 70 Kilby street. Price $5. The following is the table of contents:

Part I.—Introduction.
Methods employed in conducting the tests.
Explanation of the tables of part second.
Discussion of results.
Comparison of boilers which produce saturated steam with those producing superheated steam.
General conditions which secure economy.
Comparison of different kinds of boilers.
Comparison of different kinds of fuel,

Miscellaneous discussion.
Flue heaters.
Part II.—Tests of horizontal tubular boilers.
Tests of horizontal double-deck boilers.
Tests of plain cylinder boilers.
Tests of vertical tubular boilers.
Tests of cast-iron sectional boilers.
Tests of water-tube boilers.
Summary of tests.
Appendix.—A coal calorimeter.
A Universal Steam Calorimeter.

METALLURGY, CHEMISTRY, ETC.

The Metallurgy of Steel. By Henry Marion Howe, A. M. (Harvard) S. B. Vol. I, 1890. Published by the Scientific Publishing Company, 27 Park Place, New York. This book was first published in the Engineering and Mining Journal, commencing 1887. References are given in the book of the authorities used, it would profit most readers to examine them; contains many tables of data. The titles of the eighteen chapters are as follows:

Classification and constitution of steel.
Carbon and iron, hardening, tempering, and annealing.
Iron and silicon.
Iron and manganese.
Iron and sulphur.
Iron and phosphorus.
Chromium, tungsten, copper.
The metals occurring but sparingly in iron.
Iron and oxygen.
Nitrogen, hydrogen, and carbolic oxide.
The absorption and escape of gas from iron.
The prevention of blow holes and pipes.
Structure and related subjects; microscopic study of polished sections; fracture; changes of crystallization, etc.
Cold working, hot working, welding, punching, and shearing.
Direct processes.
Charcoal hearth processes.
The crucible steel process.
Apparatus for the Bessemer process.
Appendix: Special steels, anti-rust coatings, lead quenching.
Other volumes not yet out.

Encyclopédie Chimique. Publié sous la direction de M. Fremy, membre de l'Institut, professeur à l'École polytechnique de professeurs et d'industriels.

Tome I. Introduction. Connaissances physiques applicables à la chimie. 76 fr.
Tome II. Métalloïdes. 155 francs.
Tome III. Métaux. Ce qu'il y a de paru. 253 francs 75 centimes.
Tome IV. Analyse chimique. Ce qu'il y a de paru. 46 francs 25 centimes.
Tome V. Applications de chimie inorganique. Ce qu'il y a de paru. 250 francs.
Tomes VI, VII, et VIII. Chimie organique, proprement dite. Ce qu'il y a de paru. 418 francs 75 centimes.
Tome IX. Chimie physiologique et biologique. Ce qu'il y a de paru. 64 francs.
Tome X. Applications de chimie organique. Ce qu'il y a de paru. 100 francs 25 centimes. Cost for all the volumes purchased separately 1,364 francs.

Les souscripteurs à l'ouvrage complet, qui s'engagement à prendre toutes les parties dès l'apparition, obtiendront un rabais de 20 pour cent. sur les prix de ces parties séparées. Notamment, le prix des parties parues actuellement est réduit, pour ces souscripteurs, à 1091 francs 20 centimes.

ALUMINIUM: ITS HISTORY, OCCURRENCE, PROPERTIES, METALLURGY, AND APPLICATIONS, INCLUDING ITS ALLOYS. By Joseph W. Richards, M. A., A. C., Instructor in Metallurgy at the Lehigh University. Second edition; revised and greatly enlarged. Illustrated by twenty-eight engravings and two diagrams. Philadelphia: Henry Carey Baird & Co., Industrial Publishers, Booksellers, and Importers, 810 Walnut street. 1890.

THE ART OF ELECTROLYPTIC SEPARATION OF METALS, ETC. (Theoretical and Practical). By G. Gore, F. R. S., author of the Art of Electro-Metallurgy; The Theory and Practice of Electro-Deposition; Electro-Chemistry; The Art of Scientific Discovery; The Scientific Basis of National Progress. London: The Electrical Printing and Publishing Company, Limited, Salisbury Court, Fleet street, E. C. New York: The D. Van Nostrand Company, 23 Mutray street, and 27 Warren street. 1890.

METEOROLOGY, LAWS OF STORMS, ETC.

REMARKS ON REVOLVING STORMS. Third edition. Published by order of the Lords Commissioners of the Admiralty. Sold by J. D. Potter, agent for the sale of admiralty charts, 31 Poultry and 11 King Street, Tower Hill. 1883. Price 3d. A book of 37 pages. Gives only a few brief and general rules.

WHIRLWINDS, CYCLONES, AND TORNADOES. By William Morris Davis, instructor in Harvard College. Boston: Lee & Shepard, publishers. New York: Charles Dillingham. 1884.

A BAROMETER MANUAL FOR THE USE OF SEAMEN. Issued by the Authority of the Meteorological Council. London: Sold by J. D. Potter, 31 Poultry, and Edward Stanford. Charing Cross. 1884.

CYCLONES ET TYPHONS. Loi des dépressions barométriques dans ces ouragans et ses applications à la mer, par F. Ernest Fournier, capitaine de vaisseau. Publié avec autorisation du ministre de la marine. Paris: Librairie militaire de L. Baudoin et Cie., 30 Rue et Passage Dauphiné. 1890. Broch., in 8°. Price 75 centimes.

HANDBOOK OF THE LAW STORMS. Being a Digest of the Principal Facts of Revolving Storms. For the use of Commanders in Her Majesty's Navy and the Mercantile Marine. By William Radcliff Birt, F. R. A. S., author of "The Hurricane and Sailors' Guides," etc. A new edition, with important additions. London: George Philip & Sons, 32, Fleet street. Liverpool: Caxton Buildings, South John sreet, and 49 and 51, South Castle street.

A POPULAR TREATISE ON THE WINDS: Comprising the Atmosphere, Monsoons, Cyclones, Tornadoes, Waterspouts, Hailstorms, etc. By William Ferrel, M. A. Ph. D., late professor and assistant in the Signal Service; member of the National Academy of Sciences and of other home and foreign scientific societies. New York: John Wiley & Sons, 15 Astor Place. 1889.

THE BAROMETER, THERMOMETER, HYGROMETER, AND ATMOSPHERIC APPEARANCES AT SEA AND ON LAND AS AIDS IN FORETELLING WEATHER, with Brief Rules for their Use, and the Practical Applications of their Separate and Combined Indications as Weather Guides. Compiled from the latest and most trustworthy authorities, by Commodore Thornton A. Jenkins, U. S. Navy. Washington: Government Printing Office. 1869.

REMARKS ON THE PREVAILING STORMS OF THE ATLANTIC COAST. By W. C. Red field.

THE SAILORS' HORN BOOK FOR THE LAW OF STORMS. By Henry Piddington Griffin & Co., 2 The Hard, Portsmouth, England. Price 10s.

INQUIRY INTO THE NATURE AND COURSE OF STORMS IN THE INDIAN OCEAN. By Dr Thom.

NOTES ON THE FORM OF CYCLONES IN THE SOUTHERN OCEAN. By C. M. Meldrum.

THE LAW OF STORMS. By Col. W. Reid, C. B., F. R. S.

THE LAW OF STORMS. By H. W. Dove, F. R. S. Translated by R. H. Scott.

PHYSICAL GEOGRAPHY OF THE SEA. By Maury. Sold by Griffin & Co., 2 The Hard, Portsmouth, England. Price 6s.

ÉTUDES DES MOUVEMENTS DE L'ATMOSPHÉRE; par E. Tourinar lieutenant de vaisseau. (Extrait de la Revue maritime et coloniale.) 1890. Price, 1 franc, 25 centimes. Broch., in -8. Sold by L. Baudoin et Cie., 30 Rue et Passage Dauphiné.

PRACTICAL HINTS IN REGARD TO WEST INDIA HURRICANES. By Lieut. G. L. Dyer, U. S. Navy, 1887. Hydrographic Office. Not for sale.

THE WAY TO AVOID THE CENTER OF OUR VIOLENT GALES. 8vo. 1868. Bureau of Navigation.

HURRICANES, WITH NAUTICAL DIRECTIONS FOR AVOIDING AND MANŒUVREING IN THEM. (Pamphlet.) 1872. Hydrographic Office.

NAVAL SHIP CONSTRUCTION.

SHIPBUILDING IN IRON AND STEEL. 1869. By E. J. Reed, C. B., chief constructor of the navy, vice-president of the Institution of Naval Architects, and honorary member of the Liverpool Literary and Philosophical Society. A practical treatise, giving full details of construction, processes of manufacture, and building arrangements, with results of experiments on iron and steel, and on the strength and water-tightness of riveted work. London: John Murray, Albemarle street. By order of the Lords Commissioners of the Admiralty the examinations in practical iron shipbuilding of candidates for promotion in Her Majesty's dockyards will be mainly based upon this work.

THE MODERN PRACTICE OF SHIPBUILDING IN IRON AND STEEL. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture; member of the Institution of Naval Architects; surveyor to Lloyd's Register of Shipping. London and Glasgow: William Collins, Sons & Company, limited. 1886. Vol. I, text; vol. II, plates. May be obtained from the storekeeper at the Naval Academy. Price, $2.25.

COURS DE CONSTRUCTION NAVALE professé à l'École d'application du génie maritime. Par A. Hauser, ingénieur de la marine, chevalier de la Légion d'Honneur, sous-directeur à l'École d'application du genie maritime. 1886. Paris: E. Bernard et Cie., imprimeurs-editeurs, 71 Rue Lacondamine. Vol. I, text; vol. II, plates. Price, complete, 80 francs. Address changed to 53, Quai des Grands-Augustins.

A TEXT-BOOK OF NAVAL ARCHITECTURE FOR THE USE OF OFFICERS OF THE ROYAL NAVY. 1889. By J. J. Welch, assistant constructor, royal navy; and instructor in naval architecture at the Royal Naval College, Greenwich. Published by order of the Lords Commissioners of the Admiralty, London. Printed for Her Majesty's stationery office by Darling & Son, limited, 1–3 Great street, Thomas Apostle, E.C. To be purchased either directly or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C.; Adam and Charles Black, 6 North Bridge, Edinburgh; or Hoges, Figgis & Co., 104 Grafton street, Dublin. Price 4s. May be obtained from the storekeeper at the Naval Academy. Price, $1.38.

THEORETICAL NAVAL ARCHITECTURE. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture, etc. 1877. A treatise on the calculations involved in naval design. New York G. P. Putnam's Sons, 182 Fifth avenue, or William Collins, Sons & Co., limited, London and Glasgow. Vol. I, text; vol. II, plates. May be obtained from storekeeper at the Naval Academy. Price, $2.50.

A TREATISE ON THE STABILITY OF SHIPS. 1885. By Sir Edward J. Reed, K. C. B., F. R. S., M. P., etc. London: Charles Griffin & Co., Exeter street, Strand. Numerous diagrams and tables.

A Manual of Naval Architecture. For the use of officers of the royal navy, officers of the mercantile marine, shipbuilders, shipowners, and yachtsmen. By W. H. White, Chief Constructor, Royal Navy; member of the council of the Institution of Naval Architects; member of the Institution of Civil Engineers; fellow of the Royal School of Naval Architecture; and late instructor in naval architecture at the Royal Naval College. Second edition, revised and enlarged. The Lords Commissioners of the Admiralty have been pleased to authorize the issue of this book to the ships of the royal navy. London: John Murray, Albermarle street. 1882. Griffin & Co., 2 The Hard, Portsmouth, England. £1 4*s*.

Naval Architecture: A treatise on laying off and building wood, iron, and composite ships. By Samuel J. P. Thearle, fellow of the Royal School of Naval Architecture; member of the Institution of Naval Architects; of the controller of the Navy's Department Admiralty, Whitehall. Vol. I, text; vol. II, plates. London and Glasgow: William Collins, Sons & Co., limited. 1874. Griffin & Co., 2 The Hard, Portsmouth, England. Charge, 7*s*. 6*d*. for the two volumes.

On a Method for Calculating the Stability of Ships. By Assistant Naval Constructor D. W. Taylor, U. S. Navy. Page 157 *et seq*. Proceedings of the United States Naval Institute, vol. XVII, No. 2, 1891, whole No. 58. Price, $1. Apply to secretary of the institute.

Naval Professional Papers No. 23. The Resistance of Ships. By William Froude, esq., F. R. S. Published by Government Printing Office, Washington, 1888. The following subjects are treated in this number, all by the same author except No. 5:

1. Experiments on the resistance of a full-sized ship at various speeds, with H. M. S. *Greyhound*, in 1871.
2. Comparative resistance of long ships of several types. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.
3. Fundamental principals of the resistance of ships.
4. Experiments upon the effect produced on the wave-making resistance of ships by length of parallel middle body. Read at the 18th session of the Institution of Naval Architects, March 23, 1877.
5. Leading phenomena of the wave-making resistance of ships. By R. E. Froude, esq., with discussion. Read at the 22d session of the Institution of Naval Architects, April 8, 1881.
6. Ratio of indicated to effective horse-power, as elucidated by Mr. Denny's M. M. trials at varied speeds. Read at the 17th session of the Institution of Naval Architects, April 7, 1876.

See under Periodicals, "Transactions of the Institution of Naval Architects."

Architecture navale. Théorie du navire. By J. Pollard et A. Dudebout, Ingénieurs de la marine, professeurs à l'École du génie maritime. Four volumes (sold separately).

Volume I. Cacul des éléments géométriques des carènes droites et inclinées. Géométrie du navire. 1890. Price 13 francs.

Volume II. Statique du navire. Dynamique du navire dans le mouvement de roulis en mer calme. 1891.

Volume III. Dynamique du navire dans le mouvement de roulis sur houle. Dyrmique due navire dans le mouvement rectiligne horizontal. Résistence carène. In press.

Volume IV. Dynamique du navire dans le mouvement curviligne horizont Propulsion. Vibrations des coques des navires à hélice. In press. Pa Gauthier-Villars et fils, imprimeurs-libraires du Bureau des longitudes l'École polytechnique, Quai des Grandes-Augustins, 55.

This is the most complete work on the subject of naval architecture that ever been written, and probably the most authentic.

Guide des calculs de déplacement et de stabilité hydrostatique des navires. Par Benjamin Martinenq. Paris, E. Bernard et C., 53, Quai des Grands-Augustins, 1888. Un vol. in-4°, 202 pages, 43 figures et 6 planches. Price 20 francs.

There are many other works on this subject, but they are nearly or entirely obsolete, and Pollard et Dudebout and Hauser about cover the whole ground. The most valuable works of reference are probably the "Transactions of the Institution of Naval Architects," office 5, Adelphi Terrace, London, W. C., and to be obtained from Henry Sothern & Co., 30 Piccadilly, London, W. M. Price, £2 5*s*. Published annually. See under "Periodicals" of this list. And "Transactions North East Coast Institute of Engineers and Naval Architects," published annually by Andrew Reid, Sons & Co., Printing Court Buildings, Akenside Hill, Newcastle-upon-Tyne. London office, 4 Queen's Head Passage, Paternoster Row, E. C. Price, £3 3*s*.

NAVIGATION, SURVEYING, ETC.

Traité de navigation. Navigation astronomique. Nouvelle navigation astronomique. Théorie par M. Yvon Villarceau, Astronome de l'Observatoire de Paris, membre de l'Institut et du Bureau des longitudes. Pratique, par M. Aved de Magnac, lieutenant de vaisseau. Paris, Gauthier-Villars, imprimeur-libraire du Bureau des longitudes de l'École polytechnique, successeur de Mallet-Bachelier, Quai des Augustins, 55. 1887. Théorie et pratique, in one volume 4°, with plates, 20 francs. Volumes sold separately. Théorie, 10 francs. Pratique, prix 12 francs.

Les nouvelles méthodes de navigation. Étude critique. Par A. Ledieu, ancien officer de vaisseau, examinateur de la marine. Enrichi de nombreuses gravures intercalées dans le texte; renferment tous les nouveaux types calcul pour la détermination des droites de hauteur et du point complet à la mer (méthodes Marcq Saint-Hilaire et Pagel améliorée procédé semi-logarithmique et semi arithmétique), ainsi que pour la réduction des distances lunaires et l'usage perfectionné des chronomètres, avec application élémentaire de la théorie des erreurs d'observation. Paris, Dunod, éditeur-libraire des corps nationnaux des ponts et chaussées, des mines et des télégraphes, Quai des Augustins; 49; 1877. Prix 15 francs.

The Practice of Navigation and Nautical Astronomy. By Henry Raper, lieutenant, R. N., F. R. A. S., F. R. G. S. Ninth edition. London: Published by J. D. Potter, 31 Poultry and 11 King street, Tower Hill. Sole agent for the Admiralty Charts. Griffin & Co., 2, The Hard, Portsmouth, Eng., sell the book for 16 shillings.

U. S. Hydrographic Office, No. 65. Report on the Telegraphic Determination of Differences of Longitude in the West Indies and Central America. By Lieut. Commander F. M. Green, U. S. Navy. Prepared at the U. S. Hydrographic Office, by order of Commodore R. H. Wyman, U. S. Navy, hydrographer. Washington: Government Printing Office. 1877. Not for sale. Apply to Hydrographic Office or Bureau of Equipment.

Telegraphic Determination of Longitudes in Japan, China, and the East Indies; embracing the Meridians of Yokohama, Nagasaki, Wladiwostok, Shanghai, Amoy, Hong-Kong, Manila, Cape St. James, Singapore, Batavia, and Madras, with the Latitude of the Several Stations. By Lieut. Commanders F. M. Green and C. H. Davis and J. A. Norris, U. S. Navy, in 1881 and 1882. Published by order of Capt. J. G. Walker, U. S. Navy, Chief of the Bureau of Navigation, Navy Department. Washington: Government Printing Office. 1883. Not for sale.

Handy Book of the Stars used in Navigation. How to find them, and how to use them in getting the ship's position and correction of the compass. By Capt. W. B. Whall, younger brother Trinity House. Extra master. Author of "Handy Book of the Tides." London: George Philip & Son, 32 Fleet street. Liverpool: Philip, Son & Nephew, Chart and Nautical Publishers, 45 to 51 South Castle street.

Nautical Surveying. By the Late Vice-Admiral Shortland, LL. D., late fellow of Pembroke College, Cambridge. Published by his widow and children. London: Macmillan & Co., and New York. 1890.

A Treatise on Navigation and Nautical Astronomy. Compiled by Staff-Commander W. R. Martin, R. N. Instructor in nautical surveying, navigation, and compass adjustment; lecturer on meteorology at the Royal Naval College, Greenwich; and formerly naval assistant to the hydrographer. Sanctioned for use in the Royal Navy by the Lords Commissioners of the Admiralty. London: Longmans, Green & Co., and New York: 15 East Sixteenth street. 1888.

Report on the Telegraphic Determination of Longitudes in Mexico, Central America and West Coast of South America. By Lieut. Commander C. H. Davis, Lieuts. J. A. Norris and Charles Laird, U. S. Navy, 1885. Bureau of Navigation. Not for sale. Furnished by Bureau of Equipment or Hydrographic Office. This contains in one chapter a descriptive treatise on the various methods employed in the exchange of telegraphic time signals over submarine lines.

Report on the Telegraphic Determination of Longitudes on the East Coast of South America. By Lieut. Commander F. M. Green, U. S. Navy, 1880. Bureau of Navigation. Not for sale. Furnished by Bureau of Equipment or Hydrographic Office.

Ice and Ice Movements in the Bering Sea and Arctic Basin. By Ensign E. Simpson, U. S. Navy, 1890. Hydrographic Office.

The Use of Oil to Lessen the Dangerous Effect of Heavy Seas. Compiled by Lieut. E. B. Underwood, U. S. Navy, 1887. Hydrographic Office.

The New American Practical Navigator. By Nathaniel Bowditch, LL. D. 8vo. Edition of 1889. Bureau of Navigation. Published only by the Navy Department.

Bowditch's Useful Tables. New edition. With additional tables. 8vo. 1890. Bureau of Navigation. Published only by the Navy Department.

The Development of Great Circle Sailing. By G. W. Littlehales. 1889. Hydrographic Office. Price, $1.

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A TREATISE ON PRACTICAL ASTRONOMY AS APPLIED TO GEODESY AND NAVIGATION. By C. L. Doolittle, professor of mechanics and astronomy, Lehigh University. New York: John Wiley & Sons. 1885.

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A PRACTICAL AID TO THE NAVIGATOR. By Lieut. E. W. Sturdy, U, S. Navy. New York: John Bliss & Co. The book is intended simply to assist a practical navigator in finding his position at sea by improved methods given in works on navigation. Price, $2.

NAUTICA STIMATA AD USO DEI CAPITANI MARITIMI E DEGLI INSTITUTI NAUTICI, con travole e con figure intercalate nel testo. Per Enrico Fileti, Professore di Astronomia Nautica nel R. Instituto Gioeni-Trabia. Palermo: Libreria Internazionale, Carlo Clausen, 1891.

SPHERICAL AND PRACTICAL ASTRONOMY. By Chauvenet. Apply to Storekeeper Naval Academy.

WALKER'S NAVIGATION. Apply to Storekeeper Naval Academy. Price, $1.35.

ORDNANCE.

GUNS.

EXTERIOR BALLISTICS. By Lieuts. J. F. Meigs and R. R. Ingersoll, U. S. Navy. Second edition, revised and partially rewritten. 1887. Prepared and arranged for the use of the cadets at the U. S. Naval Academy. Printed by Isaac Friedenwald, No. 32 South Paca street, Baltimore, Md. Price $1.25. To be obtained from the storekeeper, U. S. Naval Academy.

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TEXT-BOOK OF ORDNANCE AND GUNNERY, NAVAL B. L. GUNS. By Lieuts. J. F. Meigs and and R. R. Ingersoll, U. S Navy. Prepared and arranged for the use of cadets at the U. S. Naval Academy. Second edition, revised and partially rewritten. 1887. Printed by Isaac Friedenwald, 32 South Paca street, Baltimore, Md. Price, $2.38. To be obtained from the storekeeper U. S. Naval Academy.

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NOMENCLATURE OF STEEL B. L. R. GUNS AND CARRIAGES, and MOUNTS FOR HOTCHKISS GUNS. Printed at the Torpedo Station, Newport. Furnished to ships by Bureau of Ordnance. Edition limited. Latest edition, 1890. Contains many plates. The book gives the nomenclature of such guns and carriages only as are used in the U. S. Navy. The names of the parts of the Colt's double-action navy revolver are also given.

GENERAL INFORMATION SERIES:

No. V, pages 211 *et seq.*
No. VI, Chap. IV. 8-inch B. L. R. for the U. S. Navy, and notes, pages 297 *et seq.*
No. VII, pages 336 *et seq.*
No. VIII, Chap. IV. Development of the high-power gun. Chap. V. Naval gunnery, and notes, pages 375 *et seq.*
No. IX, pages 73 *et seq.*
No. X, Chap. III.

RAPID-FIRE GUNS.

THE FOLLOWING NUMBERS OF GENERAL INFORMATION SERIES OF THE OFFICE OF NAVAL INTELLIGENCE:

No. V, pages 231 to 238.
No. VI, page 312.
No. VII, pages 336, 338, 359 to 365.
No. VIII, pages 397 to 402.
No. IX, pages 101 to 113 and 325 to 336, inclusive, being an article entitled "The development of rapid-fire guns for naval use."
No. X, Chap. III.

Copies of these numbers of General Information Series, Office of Naval Intelligence, have been furnished to naval officers, and the editions are about exhausted.

THE NEWEST FACTOR IN NAVAL WARFARE. By W. Laird Clowes. Published in the United Service Magazine for February, 1891. Price 1s.; to be obtained from the International News Company, New York.

UNITED STATES PATENT SPECIFICATIONS. To be obtained from the Commissioner of Patents, Washington, D. C. Price, 25 cents. In asking for specifications they should be referred to by number. The Official Gazette of the United States Patent Office (issued weekly, and probably to be found in every public library) contains the number and a short description of each patent issued. Annual subscriptions for Gazette, $5.

SMALL ARMS.

ALLGEMEINE WAFFENKUNDE FÜR INFANTERIE. Mit besonderer Berücksichtigung der neuesten Kriegs-Handfeuerwaffen der modernen Staaten. Von Rudolf Schmidt, Oberst. Neue Folge von 1891 zum Grundwerke von 1888. Tafeln 24–30 mit Abbildungen in Farbendruck. Bern. 1891. Verlag von Schmid, Francke & Co. (vorm. J. Dalp'sche Buchhandlung). Contains colored plates of the different parts of small arms used in the armies of France, Italy, Holland, Turkey, Austria-Hungary, England, and Switzerland, with descriptions of same. The Danish and Belgian small arms are also described. This work appears in several principal languages, and carries the subject on from 1888.

LES NOUVELLES ARMES À FEU PORTATIVES ADOTPÉES COMME ARMES DE GUERRE DANS LES ÉTATS MODERNES. Description détaillée précedée d'une étude générale des armes d'infanterie et accompagnée d'un atlas contenant 100 figures chromolithographiques. Par Rodolphe Schmidt, colonel d'infanterie, directeur de la fabrique fédérale d'armes à Berne. Bâle-Genève-Lyon, H. G org, libraire-éditeur, 1889.

TREATISE ON MILITARY SMALL ARMS AND AMUNITION, WITH THEORY ON THE MOTION OF A RIFLE BULLET. A text-book for the Army. Compiled at the School of Musketry with the assistance of the superintendent's royal laboratory, Royal small arms factory, Royal gunpowder factory, 1888. To be purchased either directly or through any bookseller from Eyre and Spottiswoode, East Harding street, Fleet street, E. C., London. Adam and Charles Black, 6 North Bridge, Edinburgh. Hodges, Figgis & Co., 104 Grafton Street, Dublin. Price, 4*s.*; interleaved, 4*s.* 9*d.*

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No. VII, pages 366 to 372.

No. VIII, pages 452 to 412.

No. IX, pages 125 to 130. Development of rapid-fire guns.

No. X, Chap. III.

PROJECTILES.

COURS D'ARTILLERIE. LES PROJECTILES. Par E. Jouffret, chef d'escadron d'artillerie Fontainebleau, typographie de Ernest Bourges, imprimeur de l'École d'application, 32, rue de l'Arbre-Sec, 1881. Used at the École d'application d'artillerie et du génie.

TREATISE ON AMMUNITION. 1887. Printed by order of the Secretary of State for War. Fourth edition corrected up to 1st January, 1887. London: Printed for Her Majesty's Stationery Office by Harrison & Sons, St. Martin's Lane, printers in ordinary to Her Majesty. And to be purchased either directly, or through any bookseller, from Eyre & Spottiswoode, East Harding street, Fleet street, E. C.; or Adam and Charles Black, North Bridge, Edinburgh; or Hodges, Figgis & Co., 104 Grafton Street, Dublin. Price 6*s.* Chapters XIII to XX inclusive treat of projectiles.

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U. S. PATENT SPECIFICATIONS referred to in another part of this list.

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THE INFLUENCE OF SEA POWER UPON HISTORY; 1660–1783. By Capt. A. T. Mahan, U. S. Navy. Boston: Little, Brown & Co.

THE GUN, RAM AND TORPEDO. Manœuvres and Tactics of a Naval Battle in the Present Day: The influence of modern ships and guns, rams, torpedoes, and other weapons on a naval action in the open sea. Prize essay. By Commander Gerard H. U. Noel, R. N. Written in competition for the prize of the Junior Naval Professional Association. 1874. With numerous illustrations. Second edition with author's preface. 1885. Griffin & Co., 2, The Hard, Portsmouth. London agents: Simpkin & Co. Price 8*s.* 6*d.*

PROBLEMS IN NAVAL TACTICS. By Vice-Admiral Randolph. 1879. Portsmouth: Griffin & Co., The Hard. London agents: Simpkin, Marshall & Co. Price, 2*s.*

REMARKS ON THE MANŒUVRES OF TWO VESSELS IN ACTION. By Lieut. G. R. Bethell, R. N. 1881. Portsmouth: Griffin & Co., 2, The Hard. London agents: Simpkin, Marshall & Co. Price 2*s.*

EXAMPLES, CONCLUSIONS, AND MAXIMS OF MODERN NAVAL TACTICS. By Commander William Bainbridge-Hoff, U. S. Navy. General Information Series No. III, Office of Naval Intelligence, Navy Department. Washington: Government Printing Office. 1884. Griffin & Co., 2, The Hard, Portsmouth, England. Price 10*s.* 6*d.*

A Treatise on Future Naval Battles and How to Fight Them, and on Other Naval Tactical Subjects. By G. Elliot. 1885. 122 pp. gr. 8vo., with 25 plates and 6 maps. 14*s*. Chap. I. Line of battle ships and torpedo vessels. Chaps. II, III. Ram and gun attack and defence. Chap. VII. Practical remarks on designs for ships of war. Chap. IX. Cellular deck protection, etc.

Coast Defence by Gunboats. By G. Elliot. 1887. 21 pp. 8vo., with 1 plate, 7 figs. (J. U. S. I.) 7*s*.

Lecture on the Turning Powers of Ships. By W. H. White, assistant constructor, R. N. Reprinted as Navy Scientific Paper No. 7, from The Journal of the Royal United Service Institution. Government Printing Office, Washington, 1882. May be obtained from Bureau of Equipment.

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Les torpilleurs, la guerre navale et la défense des côtes. Par le Vice-Amiral Bourgois. Deuxième édition. Paris, Librairie de la Nouvelle Revue, 18, Boulevard Montmartre, 1888

Nouvelles bases de tactique navale. Par l'Amiral Grégoire Boutakov. Traduites du russe par H. de la Planche, lieutenant de vaisseau. Ouvrage couronné par l'Académie des sciences de Saint-Pétersbourg, publié par ordre de S. Exc. le Marquis de Chasseloup-Laubat, Ministre de la Marine et des Colonies. Accompagné de 26 planches gravées, dont 15 en couleur, et de nombreuses figures intercalées dans le texte. Paris, Arthus Bertrand, éditeur, Librairie maritime et scientifique, Rue Hautefeuille, 21.

Études comparatives de tactique navale. Par M. Étienne Farret, lieutenant de vaisseau. Paris, Berger-Levrault et Cie., éditeurs de la Revue maritime et coloniale et de l'Annuaire de la marine, 5, Rue des Beaux-Arts, 1883. Grand in-8°, avec figures. Price 3 francs.

Les grandes manœuvres de l'escadre française. Par E. Weyl, officier de marine en retraite. Paris, Paul Ollendorff, éditeur, 28 bis, Rue de Richelieu, 1886.

Ueber Kriegführung zur See. Eine strategische Studie an der Hand der englischen Flotten-Manöver im Jahre 1888. Von Stenzel, Capitain zur See, a. D. Berlin, Weigandt und Grieben, Trebbinerstrasse, 1.

Speed, Turning, and Manœuvring Trials for Vessels of the United States Navy. General Order No. 314, signed by the Secretary of the Navy, December 1, 1883. Washington, Government Printing Office, 1883.

The Duel. A Naval War Game. Invented and arranged by Capt. Phillip H. Colomb, R. N., with explanations and rules of the game, and the necessary scales and large drawing block. Price 10*s*. 6*d*. Griffin & Co., 2 The Hard, Portsmouth, Eng. London agents: Simpkin, Marshall & Co.

Naval Warfare: Its Ruling Principles and Practice Historically Considered. By Rear Admiral P. H. Colomb, Gold Medalist Royal United Service Institution and Lecturer on Naval Strategy and Tactics at the Royal Naval College at Greenwich. London: W. H. Allen & Co., limited, 13 Waterloo Place, and at Calcutta, 1891.

The eighteen chapters treat of the following subjects:

The nature of naval war.
The struggle for the command of the sea.
The differentiation of naval force.
Attempts to gain command of the sea, with definite ulterior purpose.
The conditions under which attacks on territory from the sea succeed or f
Attacks on territory from the sea.

Fleet Manœuvring. By Pellews. Griffin & Co., 2 The Hard, Portsmouth, En land. Price 12*s*. 6*d*.

Essay on Tactics in an Action on the Open Sea with Existing Weapons. Lieut. C. Campbell, R. N. 8vo, sewn. Price 2*s*. Harrison & Sons, 59 P Mall, London, S. W.

Naval Tactics. Translated from the French by Capt. Augustus Phillimore, containing general instructions, principles of chasing, naval tactics under steam and sail. 8vo, cloth. Price 10*s.* Harrison & Sons, 59 Pall Mall, London, S. W.

Éléments de tactique navale. Par M. le Vice-Admiral Penhoot. 1879. 1 vol., grand in-8° avce, 29 figures. Broché, 2 francs 50 centimes. Berger-Levrault et Cie., 5, Rue des Beaux-Arts, Paris.

Essai historique sur la stratégie et la tactique des flottes modernes, par Chabaud-Arnault, lieutenant de vaisseau. 1879. Grand in-8°, broché, 1 franc 25 centimes. Berger-Levrault et Cie., 5, Rue des Beaux-Arts, Paris.

Études sur les opérations combinées des armées de terre et de mer, par R. Deguoy, lieutenant de vaisseau. Première partie. 1884. Grand in-8°, avec 33 figures. Price 4 francs. Berger-Levrault et Cie., 5, Rue des Beaux-Arts, Paris.

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TORPEDOES SUBMARINE MINES, ETC.

Art militaire sous-aquatique. Les torpilles. Par le Major H. de Sarrepont. 3e édition, avec supplément. Paris, Librairie militaire de L. Baudoin et Cie., libraires éditeurs, successeurs de J. Mumaine, 30, Rue et Passage Dauphine, 1883. Price 12 francs.

Instruction in Military Engineering. (Vol. I, Part IV.) Military Mining. Compiled at the School of Military Engineering, Chatham. Third Edition. Adjutant General's Office, Horse Guards, London. Printed under the superintendence of Her Majesty's stationery office, and sold by W. Clowes & Sons, limited, 13 Charing Cross, Harrison & Sons, 59 Pall Mall; W. H. Allen & Co., 13 Waterloo Place; W. Mitchell, 39 Charing Cross; Longmans & Co., Paternoster Row; Trübner & Co., 57 and 59 Ludgate Hill; Stanford, Charing Cross, and Kegan Paul, Trench & Co., 1 Paternoster Square, E. C. Also by Griffin & Co., The Hard, Portsea; A. & C. Black, Edinburgh; and Alex. Thorn & Co., Abbey street, and F. Ponsonby, Grafton street, Dublin, 1883. Price 1*s.* 6*d.*

Submarine Boats. By G. W. Hovgaard, lieutenant in the Danish navy. E. F. N. Spon, 125 Strand, London; New York, 35 Murray street, 1887.

Torpedoes for national defense. A practical and precise review of these weapons, their usefulness, application, cost, and most efficient types, together with the results obtained at official trials, and a description and comparison of the Sims, Whitehead, and Howell, based upon official reports and expert testimony. By William H. Jaques, lieutenant, U. S. Navy. Illustrated. New York and London, G. P. Putnam's Sons, The Knickerbocker Press, 1886.

Torpedoes and Torpedo Warfare: containing a Complete Account of the Progress of Submarine Warfare; also a Detailed Description of Matters Appertaining thereto including the Latest Improvements. By C. Sleeman, esq., late lieutenant, R. N., and late commander Imperial Ottoman Navy. With 83 full-page illustrations, diagrams, etc. Second edition. Portsmouth: Griffin & Co., 2, The Hard. London agents: Simpkin, Marshall & Co., 1889. Price £1 4*s.*

Submarine Mines and Torpedoes as Applied to Harbor Defense. By John Townsend Bucknill; honorary lieutenant-colonel (late major R. E.), reserve of officers; formerly (from 1873 to 1886) R. E. secretary for experiments; member and secretary for the joint War Office and Admiralty committee on experiments against H. M. S. *Oberon;* secretary of the third war office torpedo committee; assistant instructor for submarine mining, School of Military Engineering, Chatham; submarine mining officer at Woolwich; for some time acting inspector of submarine defenses at the War Office; executive officer for submarine mining in the southern district. Author of "Torpedoes *versus* Heavy Artillery," 1872. Reprinted and revised from Engineering. London: Offices of Engineering, 35 and 36 Bedford street, 1889. Treats the subject at considerable length and in great detail, and the exhaustive text is supplemented by 116 illustrations. At Griffin & Co., 2, The Hard, Portsmouth, Eng. Price 12*s.* 6*d.*

MINAS HYDRAULICAS DEFENSIVAS. Por el Coronel de Ingenieros D. Leopoldo Schneidnagel. Segunda Edicion. Madrid: Libería de Francisco Iravedra, Calle del Arenal, Num. 6, 1886.

TORPILLES ET TORPILLEURS DES NATIONS ÉTRANGÈRES, suivi d'un atlas des flottes cuirassées étrangères. Par H. Buchard, lieutenant de vaisseau. Paris: Berger-Levrault et Cie., 5, Rue des Beaux-Arts, 1889. Vol. in-8° avec 114 planches, broché, 6 francs.

LES TORPILLEURS AUTONOMES ET L'AVENIR DE LA MARINE. Par Gabriel Charmes. Paris: Berger-Levrault et Cie., 1885. Vol. in-12° broché. Price 3 francs.

LA MARINE DE LA GUERRE. SON PASSÉ ET SON AVENIR. CUIRASSES ET TORPILLEURS. Par M. Gougeard, ancien ministre de la marine. Grand in-8° avec 1 planche, broché. Price 3 francs. Paris: Berger-Levrault et Cie., 1885.

MANUEL DU MARIN-TOPILLEUR. Première partie. Électricité, suivie du Manuel spécial de télégraphie. Paris, 1890. 1 vol. in-18°, relié. Price, 3 francs. Published by L. Baudoin et Cie., 30, Rue Dauphine.

PROFESSIONAL PAPERS OF THE CORPS OF ENGINEERS, U. S. ARMY. No. 23. Report upon experiments and investigations to develop a system of submarine mines for defending the harbors of the United States. Submitted to the Board of Engineers by Lieut. Col. Henry L. Abbot, Corps of Engineers, brevet brigadier-general, U. S. Army, member of the Board. Washington, Government Printing Office, 1881.

MANUEL DU MÉCANICIEN-TORPILLEUR, publié par ordre du ministre de la marine. 2e et 3e parties. Pompes de compression. Appareils photo-électriques. Paris, 1890. 1 vol. in-8°, avec planches, relié. Price 4 francs 50 centimes. Published by L. Boudoin et Cie., 30, Rue Dauphine.

GUIDE PRATIQUE DU CHAUFFEUR ET DU MÉCANICIEN SUR LES BATEAUX-TORPILLEURS rédigé en conformité de la dépêche ministérielle du 15 janvier 1887, par E. Clergeau, mécanicien en chef de la marine. Dessins du 2e maître-mécanicien Deguy. Paris, 1888. 1 vol. in-8, relié. Price 5 francs 50 centimes. Published by L. Baudoin et Cie., 30, Rue Dauphine.

ÉTUDE SUR LES EFFETS DES EXPLOSIONS SOUS-MARINES, par J. M. S. Audic, lieutenant de vaisseau, 1877. Grand in-8, broché, 1 franc 50 centimes. Berger-Levrault et Cie., 5, Rue des Beaux-Arts, Paris.

List of publications prepared or issued from the torpedo station, Newport, R. I.

Publications.	Date.	Pages.
Torpedo experiments at Key West. Lieut. R. B. Bradford	1874	44
Lecture on drifting and movable torpedoes. Lieut. F. M. Barber	1874	40
Lecture on galvanic batteries:		
Part I. Lieut. J. P. Merrill	1874	30
Part II. Lieut. J. P. Merrill	1874	20
Part III. Lieut. J. P. Merrill	1874	40
Lecture on the Whitehead torpedo. Lieut. F. M. Barber	1874	39
Liquid carbonic acid, its preparation. Prof. W. N. Hill	1875	37
Notes on explosives. Prof. W. N. Hill	1875	60
Notes on torpedo fuzes. Lieut. G. A. Converse	1875	31
Lecture on submarine boats. Lieut. F. M. Barber	1875	39
Notes on movable torpedoes. Lieut. F. M. Barber	1875	32
Suggestions on torpedo outfits. Lieut. R. B. Bradford	1876	21
Torpedo instructions (gunpowder)	1876	84
ISSUED.		
Electricity. Lieut. Commander A. G. Caldwell	1881	21
Electrical currents. Lieut. Commander A. G. Caldwell	1881	28
Resistance and branch circuits. Lieut. Commander A. G. Caldwell	1881	37
Electromagnetism and induction. Lieut. Commander A. G. Caldwell	1881	25
Induction. Lieut. Commander A. G. Caldwell	1881	19
Electromagnetism. Lieut. Commander A. G. Caldwell	1881	19
Electrical units and constants. Lieut. Commander A. G. Caldwell	1881	28
Electrical fuzes. Lieut. Commander A. G. Caldwell	1881	65
Electrical chemistry. Lieut. Commander A. G. Caldwell	1881	31
History of torpedo warfare. Lieut. Commander R. B. Bradford	1882	96
Notes on spar torpedo. Lieut. Commander R. B. Bradford	1882	98
Notes on towing torpedo. Lieut. Commander R. B. Bradford	1882	43
Notes on movable torpedo. Lieut. Commander R. B. Bradford	1882	178
Lecture notes on torpedoes, etc. Lieut. Commander J. S. Newell	1885	90
Practical systems of electrical telegraphy. Wm. Maver, jr	1886	46

MISCELLANEOUS.

WORKS OF REFERENCE, ETC.

The Naval Annual, 1886–1891. By Lord Brassey, K. C. B. Portsmouth, J. Griffith & Co., The Hard. London agents, Simpkin, Marshall & Co.; New York agents, Van Nostrand & Co. The Naval Annual is compiled from Parliamentary Papers, the Times and Standard, Engineer, Engineering, Iron, The Broad Arrow, The Army and Navy Gazette, The United Service Gazette, The Nautical Magazine, and the Journal of the United Service Institution, The Yacht, Mittheilungen aus dem Gebiete des Seewesens, Revista Maritima, Revue Maritime, Reports of the Secretary of the Navy, and reports of United States naval officers. P. S. King & Son, 5 King street, Westminster, London, S. W., sell the book for about 10*s.* 6*d.*

Le nouveau matériél naval. Par A. Ledieu, correspondant de l'Institut de France, prix extraordinaire de l'Académie des sciences; officier de la Légion d'honneur et de l'instruction publique; commandeur, officier et chevalier de divers ordres étrangers; auteur de nombreuses publications sur les machines marines, la navigation, etc., et Ernest Cadiat, ingénieur des arts et manufactures. Vol. 1, 1889. L'ouvrage complet contiendra 260 figures intercalées dans le texte, et est accompagné d'un atlas de 50 planches. Tome premier: Balistique, agents explosifs, canons et mitrailleuses, hydraulique de manœuvre pour l'artillerie, fusils, électricité en marine, piles, accumulateurs, dynamos et magnétos, lumière et éclairage éléctriques, torpilles. 1890. L'ouvrage complet contient 300 figures intercalées dans le texte, et est accompagné d'un atlas de 51 planches et 6 grands tableaux. Tome second et dernier: Torpilles (suite et fin); torpilleurs et bateaux sous-marins; complément sur les armes à feu; appareils de sillage, de sondage et de signaux; utilisation industrielle du soleil, et production mécanique de chaud et de froid; balons captifs et libres, aéronefs et avires, pigeons voyageurs; étude technique des guerres maritimes modernes et constitution des flottes actuelles; formes et utilisation des principaux types de navires présentement en usage. Paris, Vve. Ch. Dunod, éditeur, Librairie des corps nationaux des ponts et chaussées, des mines et des télégraphes, Quai des Augustins, 49. Price, vol. I, 40 francs; vol. II, 30 francs.

Aide mémoire de l'officier de marine. Par Édouard Durassier, bibliothécaire du ministère de la marine. Commenced in 1886; published annually. Paris, Librairie militaire de L. Baudoin et Cie., imprimeurs-éditeurs, 30, Rue et Passage Dauphine. Treats of, Droit maritime international, personnel, navires, artillerie, défense des côtes tâlégraphiques sous-marins, etc., of the principal countries. One vol. in-12. Price 3 francs 50 centimes.

The Statesman's Year-Book. Statistical and Historical Annual of the States of the Civilized World for the year. Edited by J. Scott Keltie, librarian to the Royal Geographical Society. Published annually by Macmillan & Co., London and New York.

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